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Motivation

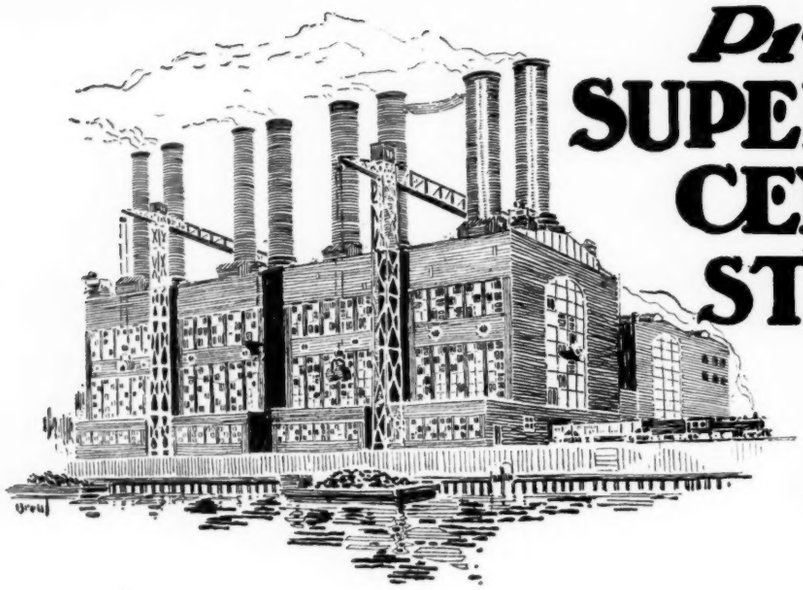
THE latest new-fangled name given to a thing we have all known for years is "motivation." A man is "motivated" if he has a definite, inspiring motive which keeps him at the work he is doing. Professor W. K. Hatt of Purdue University, in the February number of *Engineering Education*, remarks that the soldiers of the American Army were motivated the day before the Armistice was signed, but were not motivated the day after.

We all know, whether we use this new name or not, that a man must be motivated in order to get ahead around a power plant and that the principal kind of motivation is liking for the work. If a man is working simply because he needs a job, he will drift aimlessly. If, on the other hand, he is working at a given job because he likes it and has selected this job instead of others, because he likes it better than the others, he is motivated in such a way as to make his success certain.

A man who likes the atmosphere of a power plant and knows he does, will distance all his fellows. It has been said, "The world stands aside for a man who knows where he is going." Success is sure if a man knows he is going to be a specialist of some kind or other in power-plant work, or in any other kind of work for that matter, and keeps his mind fixed on this goal in spite of discouragement, because he likes this work and knows that he likes it.

The moral of this little sermon is to examine yourself in your job and see if you are really motivated by interest in your work. If not, you should try to get a job where you are so motivated, regardless of any other consideration whatsoever.

Contributed by Dr. S. A. MOSS



Proposed SUPER-POWER CENTRAL STATION

by John A. Stevens*

Relates to a proposed design of super-power station built with multiples of 30,000-kw. units up to a total station capacity of, say, 100,000, 300,000 or even 500,000 kw. Each unit consists of four 1,716-hp. boilers, normal rating, served by one stack centrally located, and supplying steam to one 30,000-kw. turbine. All boiler houses are separated from their turbine rooms by an explosion gap, and the turbine rooms are separated by explosion walls. All station refinements are incorporated in this design of station, and a main operating room is provided at the top of the station, together with sleeping quarters for the men, baths and showers, telephones, searchlight, alarm whistle and wireless apparatus.

IN THESE days, when one hears so much regarding the great central stations that are being constructed and developed in Europe and in this country, it is worth while to consider the super-power station illustrated in the supplement to this issue of *Power*.

There is a tendency more and more toward the super-station, and a point has been reached in steam and electrical engineering where the super-station is of vital importance to the success of all great industrial centers, in that substantially one-half of the average coal consumption will be used and a probable reduction of men and payroll per kilowatt output will result as compared with some types of large power stations. The indications are that in the comparatively near future the more important railroads of this country will be electrified, for it seems adverse to steam and electrical engineering that each train should be supplied with a complete individual power plant such as, with a few exceptions, is the present locomotive practice.

The super-station should be used to relay and reinforce hydro-electric developments where possible, and to supply practically all the energy to manufacturing and other plants, outside of the power that can be made as a byproduct to manufacturing and heating steam requirements, which are usually supplied by non-condensing engines and non-condensing turbines of various types.

Furthermore, an infinite number of electrical uses are being created annually, which means a larger production of electricity than was dreamed of even ten years ago, provided the cost of electricity can be kept down to a point that will enable its more general use. In order to carry power-plant engineering to the last degree of economy, some features are suggested in the design shown by the supplement, which may not be adopted at the present time, but sooner or later will have to be taken into consideration in order to carry out the economical program suggested.

Now that the cost of coal has advanced, and is sure to advance more, it becomes of the greatest importance to engineers, as well as to financiers, to look to the most advantageous arrangement of a station of, say, 100,000 to 300,000 or even 500,000 kw. The supplement illustrated is the suggestion of one group of engineers for such a station, and although the principle involved may not be adopted, this design may suggest to others features that will be of benefit to this country's economies, with special reference to the minimum use of coal and men.

In the working out of this power-plant design, the engineering ideas of many men are embodied in certain features, and these ideas have been combined and worked into a completed harmonious whole.

Thirty-Thousand-Kilowatt Units Recommended

The idea of specifying a particular size of units (30,000 kw.) is that this size is within the zone of maximum economy in steam-turbine engineering practice, and further, it is about the limit of size that can be supplied with four sections or units of boilers served with one central stack. Four boiler units are installed so that one may be out for inspection, repair or cleaning at any time, and the station still be capable of developing its full electrical output.

With the present advance of electrical transmission systems and the use of high voltages, the opportunity to locate such a super-station either at or near the coal mines or on large and navigable rivers or at tidewater,

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is available. In making hypothetical station layouts, the engineer should consider all possible kinds of fuel in the suggested arrangement of the stations.

The particular station illustrated is a tidewater proposition with railroad facilities, together with a very large water supply, which is necessary.

Rail facilities are almost necessary for successful building and operation of a station of this kind and class, as it is desirable that full-size railroad cars and large locomotives pass through or under the station for the handling of the enormous bulk of coal to the ashpits, and also under the soot pipes that handle the soot from the stack, as illustrated.

It is doubtful if engineers know to what extent power stations may increase in size, and it is suggested that no project of this kind should be started where the ultimate possible development, if so desired, could not be made at least 250,000 kw. There is no object in putting money into power-plant investments and then to do practically the same thing over again. In other words, money should be used with a breadth of character sufficient to meet any demand. As Americans, we are

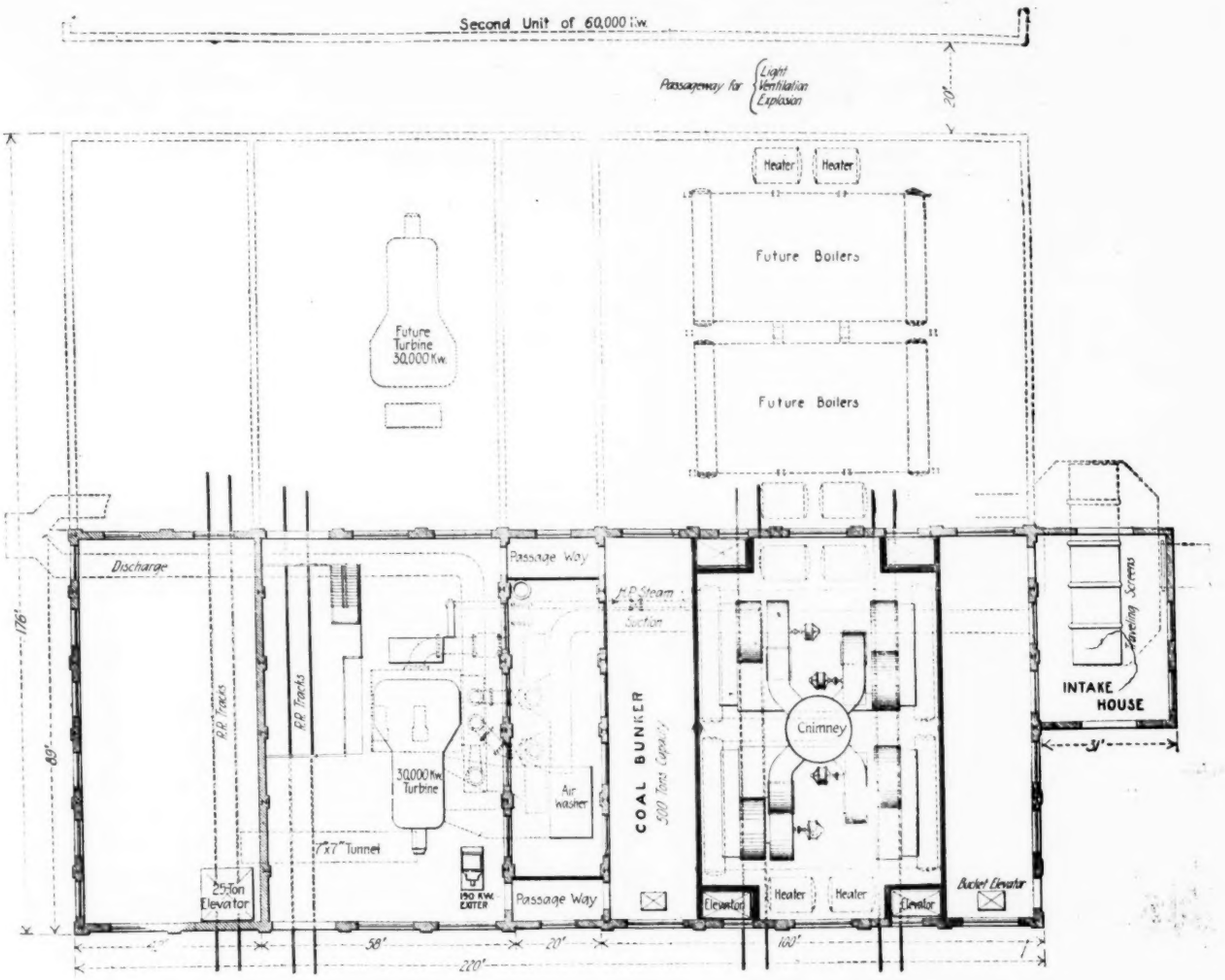


FIG. 1. PLAN VIEW OF A THIRTY THOUSAND-KILOWATT INSTALLATION
Showing four 1,716-hp. Stevens-Pratt Boilers and one 30,000-kw.turbine. Dotted lines indicate duplicate installation, making a total of 60,000 kw. for a complete unit

station and ashes and soot from the station, to say nothing of the economical handling and the installation of new equipment, such as boilers, condensers and turbines, or the loading of old equipment whenever it is necessary to ship by rail to the builders for overhauling.

Railroad cars of the largest capacity should be available under the main cranes of the station for handling with the greatest facility the heavy parts of turbines, boilers, condensers, etc. If a station of this size and kind is located at tidewater, where railroads are not available, large floating cranes may be used in lieu of the railroad service. It is proposed to use a locomotive for shifting the largest-sized railroad cars under always building ourselves into some location where we cannot expand as our business expands, and the abandonment of existing equipment is a very expensive procedure.

General Arrangement of Station

In the supplement 1,716-hp., normal rating, Stevens-Pratt boilers are shown. They are arranged in units of four, with one central stack, which is from 300 to 350 ft. high, in order to discharge the escaping gases and incidental dust which may pass the soot separators (not shown) at high altitudes. Stirling Stevens-Pratt boilers may be advantageously used when desired. The four boilers indicated contain about 31 miles of tubing.

The suggested development requires that the boilers be installed in practically an independent building, as illustrated, with an outdoor passageway between it and the turbine room and a connecting covered bridge (not shown on the drawing) between the boiler-house operating room, which is shown at the top of the drawing, and the switchhouse operating rooms shown at the top of the switchhouse.

Although boilers are now so designed in this country that it is not expected that where plants are properly installed, there will be many more major explosions, minor explosions and derangements, such as tube failures and steam-pipe and fitting failures are to be expected for some time to come. It is desirable, therefore, to provide, primarily, for such derangements, to say nothing of guarding against the results of electrical short circuits in generators, and also as a matter of human protection, if not for financial reasons.

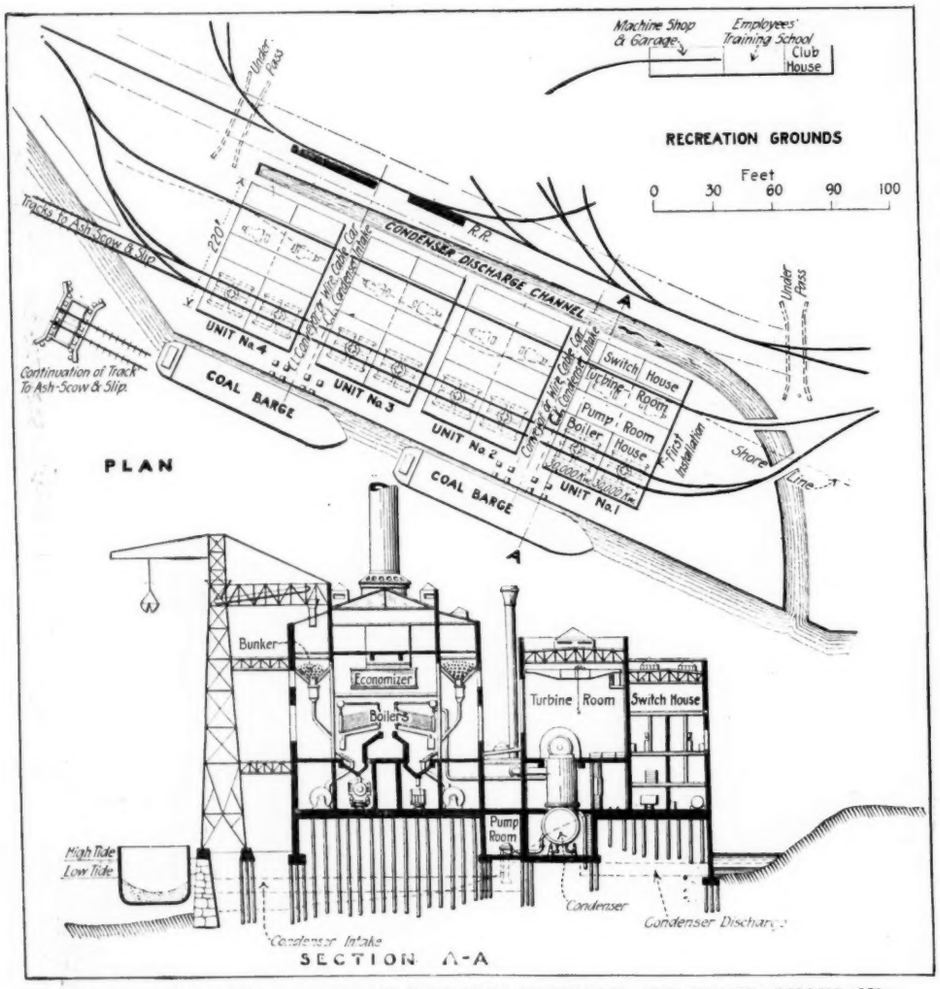


FIG. 2. PLAN AND ELEVATION OF A TWO HUNDRED AND FORTY THOUSAND-KILOWATT SUPER STATION

Note the explosion gaps between each 60,000-kw. unit.

In leaving the explosion gap (so called) between the boiler room and the turbine room, a facility of light and ventilation is made possible in both rooms; it also localizes the damage to the plant if an accident occurs.

The switchhouse is designed with fireproof explosion wall with no opening next to the turbine room, and to insure continuity of service, double busbars are provided so that one set may be out of order and undergoing repair and inspection while the other carries the load.

Another safety provision is incorporated in dividing each group of turbine rooms themselves by protecting walls which reach to the crane height. In the instance of the bursting of steam mains or fittings, if the operators are protected by a wall 25 or 30 ft. high, there is some chance for them to escape, unless the explosion is very disastrous. Some engineers, however, might prefer to divide each group of turbine rooms into two separate compartments, using two cranes. This is a matter of choice for individual designers. Still further, each 60,000-kw. capacity power house should be separated from the next unit of the same size by a space 20 to 40 ft. in the clear. The electrical ends, however, can be connected at the transformer station, whether it is outside the station or inside the switchhouses. This colossal boiler plant is illustrated as resting on piles, somewhat proportionate as to the loads to be supported; for usually, in harbors and along river banks in the course of the past ages, a good deal of silt has been washed in and along the river beds, and portions of bays and harbors have receded and left a great deal of soft material. Foundations so located must be built on piles, preferably with a series of piles at the panel or pressure joints, a slab, designed to support all loads, wind loads as well as gravity loads, six to eight feet thick, reinforced top and bottom with steel, and the columns should be anchored down, because the pull at times and with different loads imposed on the station and stack may be upward. Sleeping quarters for the men are arranged on the basement floor and if desired in other designs, air heaters can be installed where the sleeping quarters are located in this particular design.

As to heating the air which supports combustion, it is not advocated that a very high temperature be maintained, but a moderate degree of heat shows a decrease in the amount of coal consumed per kilowatt on the outgoing leads of the station, the steam being extracted from the high-pressure stages to supply these heaters when used.

The basement also contains the large turbine—and motor-driven forced-draft fan for the stokers, as well as all other auxiliaries in the station. This combination is used so that the heat balance may be correct without

wasting hot water or steam, a condition with which all engineers are familiar. Adequate railroad scales, coal bunkers, coal-crushing rolls and coal-handling apparatus are also shown, together with a small machine and pipe-threading shop, and the necessary storerooms located above them for rough material such as spare tubes, tile, asbestos, etc.

On the firing floors stands are provided for the main motor-actuated stop valves. These may be controlled by remote motor controls from the switchhouse or from any part of the plant. This is an important part of the boiler-plant design, and there is also a permanent platform at or near this valve to permit of its inspection, overhanging or repair. A master valve at or near all boiler plants of this size, with motor-operated connection, is desirable, so that the valve may be closed from any point, in the event of serious disaster in the turbine room. The main piping is hung on springs, so that it may expand and contract at will without straining the flanges, fittings or piping.

The main steam pipe is designed in what amounts to a loop around the boilers, with double valves on each boiler lead or take-off. The valve rods extend to the operating room. The valving is so arranged that any boiler section may be taken out of service at pleasure, and the loop arrangement provides for the expansion and contraction in any direction without the straining of the pipe, fittings or valves. A master branch runs from the boilers with the shortest possible length of piping to the main turbines and their auxiliaries. Most of the bends are at 90-deg. angle, but some of them are 45 deg. in order that the minimum-sized piping may be used with the highest velocity without scoring or erosion of the piping, valve seats, fittings, etc. Turbine-boiler-feed pumps are used, located in the fireroom for the greatest accessibility. The fans, pumps and economizers for this entire installation should be individual for each main unit, with cross-connections on the feed lines so that feed water may always be obtained quickly if one or even two units should fail. The area shown between the operating floor and the floor supporting the induced-draft fans is really the high-temperature area in this plant. This area is to be double-cased at the boilers, so that the ingoing air may be drawn in and over the casings, and through the passageways and hollow bridge walls to the forced-draft fan inlets for the partial warming of the air used to support combustion in the furnaces.

The design of the bridge walls is such that they are really rooms or corridors, and because of this feature the engineers may make their furnaces practically any length they desire and still have accessibility to practically any part of the furnace through the doors in the bridge walls—not a new idea but a good one.

Weighing larries for coal distribution to any of the furnaces are provided for, as well as a suitable recording system. There is also a lighting system, even to the individual lights on the coal larry and for moving up and down over the tube areas for inspection and cleaning.

On the floor or platform below the induced-draft fans will be seen the economizers of a type that it is believed is fast coming to the front. They are a combination of cast-iron sections and steel sections through which the water is pumped in series.

On a level with the coal-handling system is shown the induced-draft fan room. These fans are driven, as are the forced-draft fans, by steam turbines as a relay to the motors and for facility in keeping the heat balance correct.

In the operating room there is incorporated every known device for testing boilers, permanently installed and connected, so that in a clean, bright, well-lighted room with the roof of the station of wire-insertion plate glass, the master boiler operator can make hourly boiler tests, of the output of the boilers, if he so desires. Periscopes are provided for observation of the furnaces and periscopes for reading the water gage-glass levels as well.

On this level a remote-control whistle valve and a platform for taking care of it are shown. Whistle valves are hard to keep tight, and the platform is provided for the handling of this valve. In all cities or localities where such a station is built there should be a whistle 12 in. in diameter by 4 ft. long, which could be heard for miles, for signaling all kinds of service, such as militia, rioting and fire, and to give other signals, even if the station is located in what is more or less of a rural district.

Naturally, the operating room contains the necessary desks, and there is also provision for wireless apparatus. One large company in this country is sending 60 per cent of its messages by wireless, the aërial being connected to the stacks. If this innovation has proved so successful to a commercial organization, why not adopt the idea? On the penthouses above the elevators will be seen searchlights, which are desirable for the protection of a great station of this kind. All large stations should be provided with elevators for transporting the operators from one floor or gallery to another, and also to carry up and down station equipment such as large valves, auxiliary turbines and motors, etc. This station is so designed that, in so far as possible, no planks or tackles will be necessary. This avoids the use of a large number of men who are non-productive except in emergency cases.

Another progressive feature is that telephones are provided at all important points or where needed. A man should not have to walk over twenty-five feet to reach a telephone at any point in this great station. Although not shown on the drawing, telephones are placed at or near the boiler-drum manholes, so that it is not necessary for a man to climb out of the drum and down the ladder to tell the chief engineer that he has found a certain defect, etc., in the boiler drums. Telephones are also placed near the fans on the larry gallery. These fans are to supply outside cool air to the hot sections or parts of the boiler when they are under inspection and repair. Naturally, a station of this size should be fitted with large air compressors to supply air for cleaning the boiler tubes and for doing all sorts of mechanical and other work around the plant.

The intake house should be designed with cranes, be steam-heated and have proper flushing connections so that at certain seasons of the year, when the condens-

ing water has grown rather foul with leaves, etc., it may be practically automatically cleaned.

Many other features will be observed in the design of the boiler plant, if carefully studied. For instance, note the pipes running above the umbrella on the stack and at the base of the umbrella; these may be used to wash off the dust that may collect on the plate-glass roof. Underneath the plate-glass roof will be observed a shade on rollers, so that on a hot summer's day the operating room may be shaded and made comfortable. In the stack casing (similar to a transatlantic liner's casing) will be observed a reproduction of the boiler drums, from which the water levels may be read by the flashing of a light in addition to the periscope leading down to the water columns on the boilers and also the water gages installed on all these great units. In other words, there are three ways in which the operator can observe the water levels in the boilers.

Under the platform or roof over the space between the main boiler plant and the turbine room may be placed the main circulating pumps, both turbine- and motor-driven, for the condensers, air compressors, condensate and dry-air vacuum pumps, and the usual pump-room machinery.

Beneath the floor can be placed, if so desired, the intake tunnel, for which the main walls of the boiler plant and the turbine room make the side walls. That is to say, there are no heavy loads imposed on this area between the two main buildings, the boiler plant and the turbine plant.

STANDARDIZATION TABLE OF THE STEVENS-PRATT BOILER

Possible Output in Kilowatts, allowing 30-lb. Water per Boiler Horsepower per Hour and 12-lb. Steam per Kilowatt-Hour, including Auxiliaries in Turbine Plant

350 *Lb. W. P.* + 250 *Deg. F. Superheat*

Size of Sections in Boiler Hp. Rated on Sq.Ft.	No. of Sections in Operation	Per Cent Rating of Sections 100	150	175	200	250	300	400
		Kw.	Kw.	Kw.	Kw.	Kw.	Kw.	Kw.
500	4	5,000	7,500	8,750	10,000	12,500	15,000	20,000
	3	3,750	5,625	6,562	7,500	9,375	11,250	15,000
600	4	6,000	9,000	10,500	12,000	15,000	18,000	24,000
	3	4,500	6,750	7,875	9,000	11,250	13,500	18 000
750	4	7 500	11,250	13,125	15,000	18,750	22,500	30,000
	3	5,625	8,437	9,844	11,250	14,062	16,875	22,500
1,000	4	10,000	15,000	17,500	20,000	25,000	30,000	40,000
	3	7,500	11,250	13,125	15,000	18,750	22,500	30,000
1,250	4	12,500	18,750	21,875	25,000	31,250	37,500	50,000
	3	9,375	14,063	16,410	18,750	23,438	28,125	37,500
1,350	4	13,500	20,250	23,625	27,000	33,750	40,500	54,000
	3	10,125	15,187	17,719	20,250	25,312	30,375	40,500
1,450	4	14,500	21,750	25,375	29,000	36,250	43,500	58,000
	3	10.875	16,312	19,031	21,750	27,187	32,625	43,500
1,550	4	15,500	23,250	27,125	31,000	38,750	46 500	62,000
	3	11,625	17,437	20,344	23,250	29,062	34,875	46,500
1,716	4	17,160	25,740	30,030	34,320	42,900	51,480	68,640
	3	12,870	19,305	22,520	25,740	32,175	38,610	51,480

The main turbine room is necessarily a very simple affair and is clearly illustrated on the drawing to bring out the main points.

Where high river water is to be contended with, due to high spring rises or flood conditions, or where the tide levels and the railroad levels are markedly different, the main condenser may be placed in a pit and the eduction pipe, or exhaust pipe, between the turbine and the condenser made any reasonable length to give the proper elevation and have the usual siphoning effect through the condensers; the main idea being that the turbine-room levels and the boiler-room levels should be the same. In designing the switchhouse, provision should be made so that a full-sized railroad car should be able to pass through one section. The elevators and elevator beams should have a capacity great enough to lift any equipment necessary in the oil switchroom, or the reactance or cable rooms.

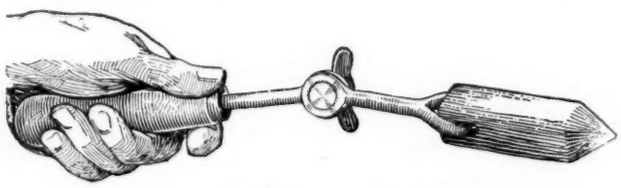
As a precaution against damage to the generating units a check valve, made of heavy plate, is placed at the warm-air discharge to the stoker fan, so that in the event of a minor explosion in the tube area of the boilers, the dust and soot would not be blown into the main turbine generator.

Several arrangements may be used for handling the coal supply. That shown is a large coal tower located on the dock. There is also an outdoor transformer station, and the ash-scow slip, similar to a ferryboat slip for handling regular railroad cars on a scow which may be towed to sea for dumping. This development was conceived in 1917, but the idea lay dormant during the period of the war. As previously mentioned, the ideas and suggestions of many have been interwoven into this design, showing the art up to the present time, and it is desired to give credit to anyone who sees some of his special designs embodied in this illustration, which is presented to the public for the good of the service.

Handy Soldering Iron

BY M. A. SALLER

It is frequently necessary to do soldering in out-of-the-way places where a straight-handled soldering iron would prove to be an awkward tool. I have made a soldering iron, as shown in the sketch, the handle rod being provided with eyes and a thumbscrew bolt and nut at the middle, so that the iron can be adjusted to any desired angle, or held in the normal straightway position.



ADJUSTABLE HANDLE FOR SOLDERING IRON

Domestic exports of electrical machinery and appliances from the United States during March were as follows: Batteries, valued at $690,866; carbons, $128,531; dynamos and generators, $464,178; fans, $115,069; incandescent lamps (carbon filament), $19,986; (metal filament), $427,348; magnetos, spark plugs, etc., $440,240; motors, $1,247,806; switches and accessories, $356,631; transformers, $347,195; miscellaneous, $2,966,103. The report which is issued by the Department of Commerce, Bureau of Foreign and Domestic Commerce, Washington, D. C., shows Canada well in the lead over all other countries in the value of her imports from the United States.

Vertical-Shaft Waterwheel-Driven Alternators — Lubricating System and Rotor

Typical Systems Used To Lubricate the Various Bearings of a Vertical Alternator; Influence of Flywheel Effect on Speed Variation and Dimensions of Rotor; Safe Speeds and Different Rotor Constructions

By S. H. MORTENSEN
Electrical Engineer, Allis-Chalmers Manufacturing Company

PROPER lubrication of the different bearings on a vertical alternator is of great importance, and many different systems, some elaborate, are in service. In Fig. 1 is shown the oiling arrangement for a vertical machine with a thrust bearing and two guide bearings on the generator. As the arrows indicate, the oil is pumped through a system of piping to the top of the machine by a small geared oil pump mounted in the lower oil pan. At the point marked A the oil flow is divided into two paths. The main path leads to the top guide bearing, through this bearing, through the lower bearing and back to the main oil pan. The second path leads through the thrust bearing. The amount of oil flowing through this pipe is small, just sufficient to compensate for evaporation, leakage, etc. The heat generated in the thrust bearing is carried off by means of a cooling coil located in the oil bath surrounding the bearing, as indicated in the figure. A sufficient amount of cool water is circulated through the coil to limit the oil temperature to a safe operating value. No special means are provided for cooling the oil from the guide bearing other than circulating it through the piping system.

Oil gages with drain cocks are provided for the thrust-bearing housing and lower oil pan, and a sight-flow indicator is mounted in a prominent position. The hand on this indicator takes different positions for different oil velocities and by means of an electric circuit may be arranged to ring a signal bell if the oil flow for some reason is stopped. A drain is provided in the thrust bearing to prevent flooding. As the oil pump is called upon to overcome only the weight of the oil column between the upper and lower oil levels, it can be of simple design, such as a small plunger pump or a centrifugal pump of the geared type. In some installations this pump is mounted outside the oil pan and operated from the mainshaft by a chain drive.

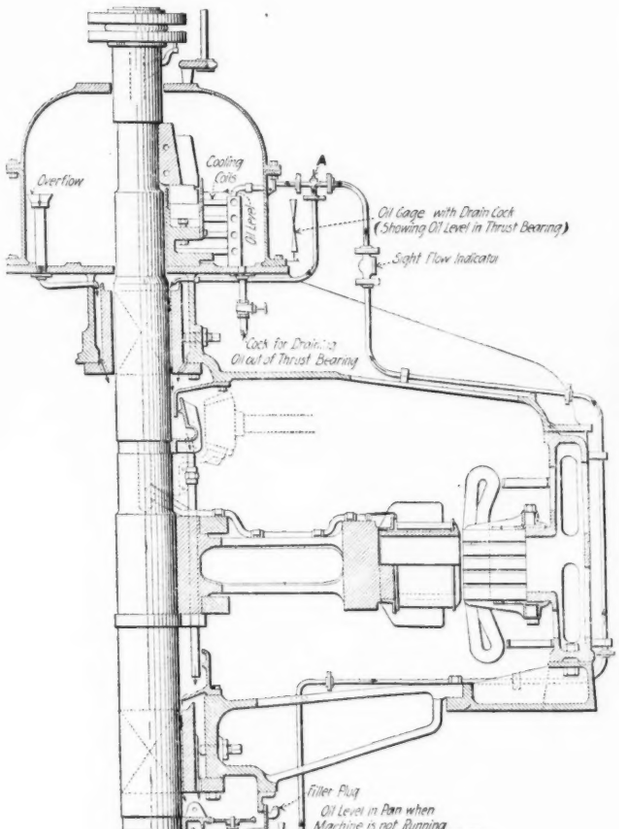

Overflow
Cooling Coils
Oil Level
Oil Gage with Drain Cock (Showing Oil Level in Thrust Bearing)
Sight Flow Indicator
Cock for Draining Oil out of Thrust Bearing
Filler Plug
Oil Level in Pan when Machine is not Running
Oil Gage with Drain Cock
Oil Pump for Circulating Lubricating Oil

FIG. 1. LUBRICATING SYSTEM FOR GENERATOR WITH THRUST BEARING AND TWO GUIDE BEARINGS

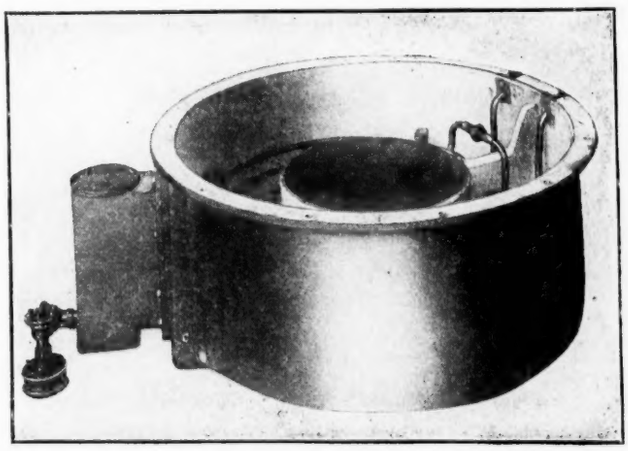


FIG. 2. OIL-PAN, COOLING COIL AND STRAINER

On some large vertical generators a somewhat more elaborate oiling system is used. The oil for the thrust bearing is circulated by the oil pump through the piping system to the thrust bearing and from there back again to the main oil pan, where it is cooled by a coil with water circulation. After it is cooled, the oil passes through an oil strainer back to the pump, thus completing the cycle. From the guide bearings the oil completes a similar circuit. Gate valves and oil-flow indicators, together with sight glasses, provide means for checking and adjusting the

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oil flow. Fig. 2 shows the oil pan, cooling coil and oil strainer.

The method of lubrication varies with the capacity of the generators and with the size of the power station. Frequently, large stations have elaborate oiling systems with oil filters and separate motor-driven oil pumps. However, the tendency at the present time is to simplify the system, and in one of the most recent installations the oil in the thrust bearing is not circulated, but kept cool by cooling coils. The oil lost by leakage or evaporation is then replaced at regular intervals. The only function of the oil pump is, in these cases, limited to circulating the comparatively small amount of oil required for the lubrication of the guide bearings. Large machines frequently have glass windows in the thrust-bearing cover and electric lamps mounted inside the cover, thereby providing ample opportunity for inspecting the bearing parts. It is important to check the temperature of the different bearings to guard against accidents, therefore recording thermometers are usually supplied with the more important machines.

Usually designated as WR^2, the flywheel effect required for the proper speed variation of hydraulic units frequently determines the diameter and also the weight of the direct-connected alternator's rotor. As it thus has a direct bearing upon the design of the machine, a short discussion of the different factors involved may be of interest. As the hydraulic turbine develops a uniform torque throughout the revolution, the only

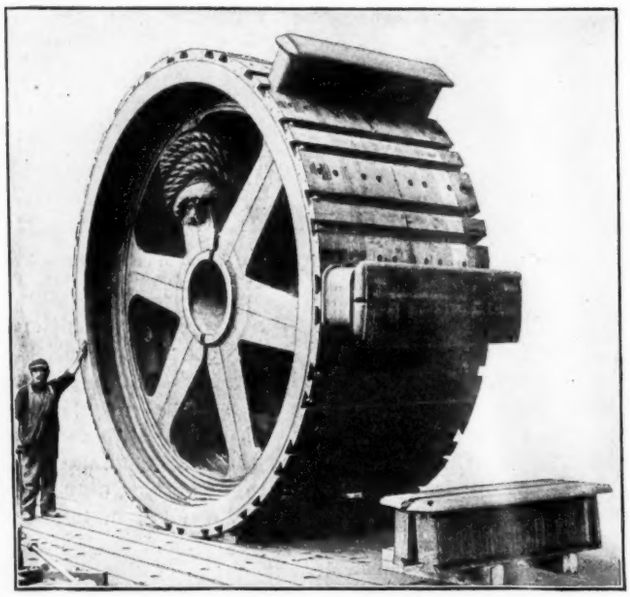


FIG. 3. ROTOR SPIDER OF ONE OF THE BIG NIAGARA FALLS UNITS

function of its rotor flywheel effect is to restrain speed variations during the periods of load adjustment.

The simplest case of speed regulation is found in open flume installations, where the energy of the moving water column can be neglected. In such installations the speed regulation depends upon four factors: P, the load variation of the unit in horsepower; T, the time in seconds required by the hydraulic governor for the opening or closing of the turbine gate; WR^2, the inertia of the rotating masses expressed as a product of the rotor weight and the square of its radius of gyration; and S, the rotor speed in revolutions per minute.

Let V equal the ratio of the increase of speed to the normal speed, then the relation between the factors involved is found in the equation,

$$V = \frac{A \times P \times T}{WR^2 \times S^2}$$

In this equation A is a constant. The speed change V increases with the amount of load thrown off or

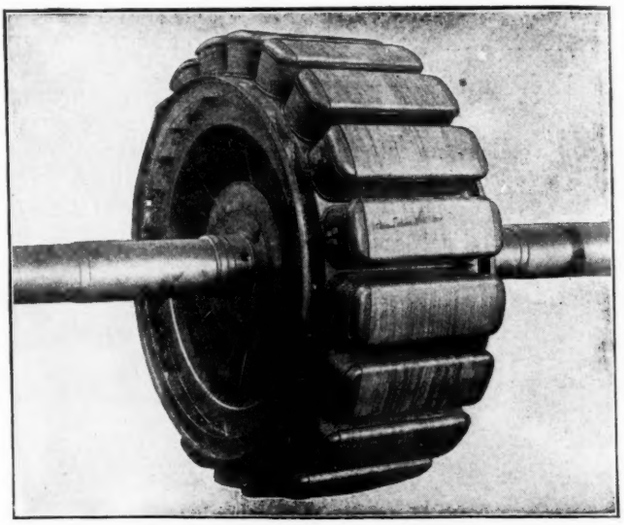


FIG. 4. HIGH-SPEED ROTOR COMPLETE

on, and it also increases as the time required for opening or closing the turbine gate increases. On the other hand, V decreases with the increase in the rotor WR^2 and also as the square of its revolving speed. The equation is based on the assumption that the energy stored in the water column leading to and away from the turbine is without influence upon its speed regulation. This is not the case.

In installations with long penstocks and draft tubes, energy is liberated or absorbed by the acceleration or retardation of the water column. For such installation either surge tanks or standpipes should be provided, or the governor should be adjusted to give slow gate action, as otherwise dangerous hydraulic surges will be set up under load fluctuations.

It is apparent that no hard and fast rule can be laid down for the WR^2 required to give successful speed regulation. For the purpose of comparison it is expedient to reduce the alternator WR^2 to a value K corresponding to 1 hp. at 1 r.p.m., which gives

$$K = \frac{WR^2 \times S^2}{P}$$

Values for K thus derived vary over a wide range. In installations with long pipe lines and large load fluctuations, a value of $K = 14{,}000{,}000$ may be necessary to insure satisfactory operation. On the other hand, systems with steady loads and short pipe lines may give good regulation with $K = 2{,}000{,}000$. The flywheel effect of the turbine runner is generally negligible, and this makes it necessary to embody the required WR^2 in the alternator rotor. If the WR^2 of a proposed machine falls short of the momentum re-

quired by the waterwheel builder, it may be increased within limits, either by making the diameter of the alternator rotor larger or by increasing its weight. In high-speed machines the rotor diameter is generally as large as the mechanical strength of its material permits, and in that case additional weight must be added to the rotor spider.

An increase in the WR^2 invariably means an increase in the cost of the machine, together with a decrease in its efficiency, due to additional windage and friction losses of the rotor. For that reason the WR^2 specified by the waterwheel builder should be kept as low as permissible to give satisfactory electrical operation. It should be borne in mind that speed fluctuations affect only the frequency and voltage of an electrical system; also that a momentary fluctuation of the frequency is not objectionable.

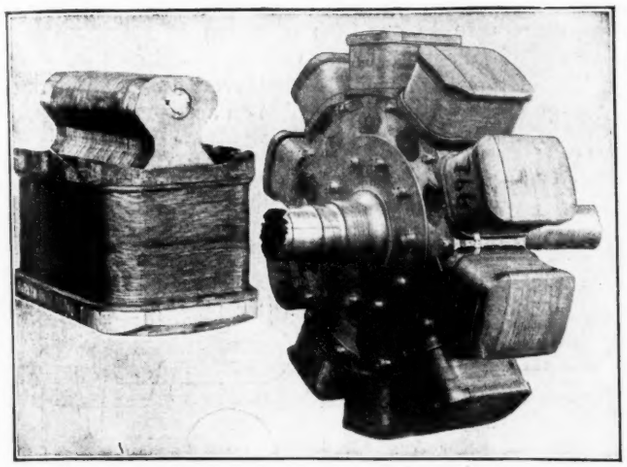


FIG. 5. ROTOR DESIGNED FOR EXTREMELY HIGH PERIPHERAL VELOCITY

On systems where close voltage regulation is required, it is as a rule necessary to provide automatic voltage regulators, not alone on account of the speed fluctuations on the turbine, but also on account of the voltage regulation of the alternator.

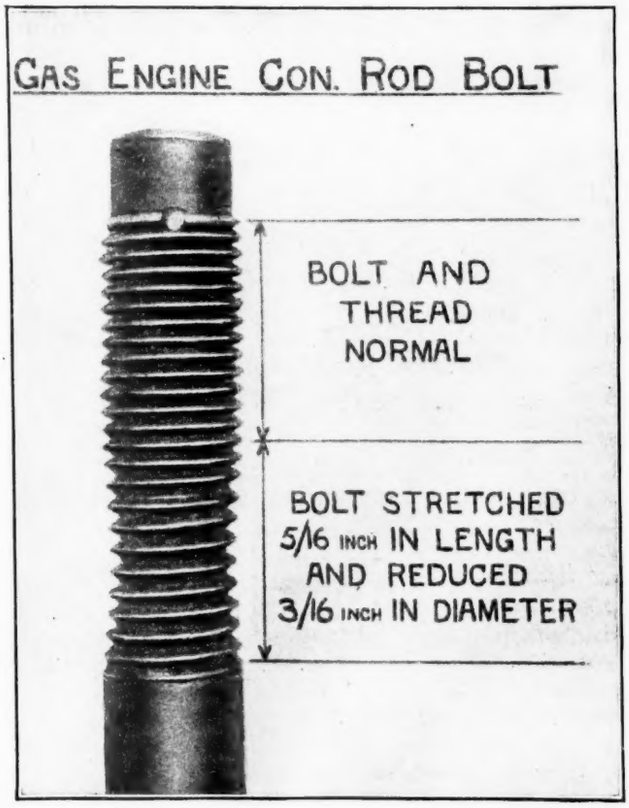
It should be remembered that the WR^2 of all the synchronous machines, such as motors, motor-generator sets, frequency-changer sets, rotary converters, etc., connected to the power system, is just as effective during speed fluctuations as if their momentum was embodied directly in the rotor of the alternator. As soon as the speed of the turbine unit changes, a similar change takes place in the speed of all the connected synchronous machines, whose rotating part then either absorbs energy from, or gives energy back, to the power system.

The runaway speed of a hydraulic turbine determines the maximum stresses imposed upon the direct-connected alternator's rotor. For different installations this speed varies between 1½ and 2 times the normal generator speed. Generally, the rotor is proportioned to limit its stresses at runaway speed to less than one-half the elastic limit of the respective material. This gives an ample factor of safety to take care of the hidden defects in the material and practically eliminates mechanical failures due to overspeeds.

Figs. 3 to 5 show different rotor construction for medium- and high-speed vertical machines. Fig. 3 is the rotor for one of the 32,500-kva. generators installed recently at Niagara Falls. The sizes of the rotor poles made it expedient to divide them into symmetrical halves, each half joined to the spider by an individual dovetail. Fig. 4 shows a high-speed rotor for a 14,200-kva. vertical generator installed in a plant of the San Joaquin Light and Power Co. A rotor field pole and the partly assembled rotor for a machine with extremely high peripheral velocity are shown in Fig. 5, the method of attaching the polepieces to the rotor being clearly indicated.

The Effect of Loose Nuts on Connecting-Rod Bolts

In a discussion of failures of connecting-rod bolts in internal-combustion engines in "Notes on Gas and Oil Engine Accidents," by the National Boiler and General Insurance Co., Ltd., of Manchester, England, attention is called to the danger from running with the nuts slacked off. These bolts are commonly fitted with double nuts, so that when adjusted and tightened up, the nuts may be locked together; they are further fitted with a split pin for security. When first sent out from the shop, this split pin is hard up against the outer nut, but after the brasses have been adjusted once or twice, there will be a clearance between the pin and the nut. This clearance should be filled up with washers, so as to prevent the nuts from slacking back.



EFFECT OF RUNNING GAS-ENGINE CONNECTING-ROD BOLT WITH SLACK NUT

The illustration is reproduced from a photograph of a connecting-rod bolt that had been severely stressed through being allowed to work with the nuts slack. The bolt was taken out of the engine just in time, as it was stressed considerably beyond the elastic limit of the material and was evidently on the point of failure.

Refrigeration Study Course—X. Automatic Refrigeration

By H. J. MACINTIRE

THERE are many applications of refrigeration which require intermittent work, but especially is this true of motor-driven small-sized cold-storage plants. Being motor-driven, usually of the induction or sometimes the synchronous type, it is not practical to provide variable speeds to adjust the speed to the load. Also it is desirable where possible to have a machine that is capable of temperature control, one that will be semi-independent of constant care or that will operate by night or day subject to occasional supervision on the part of the engineer.

This desire for an automatic refrigerating machine applies more particularly to the small machine, where the plant does not warrant the cost of additional operators. For very small plants the use of "holdover" tanks, or the brine system with large storage tank and continuous brine circulation, has for some time met with considerable success. However, the holdover tank requires considerable additional headroom, because a tank containing brine and one-third of the total amount of expansion piping must be arranged at the top of the cold-storage room. The submerged piping is expected

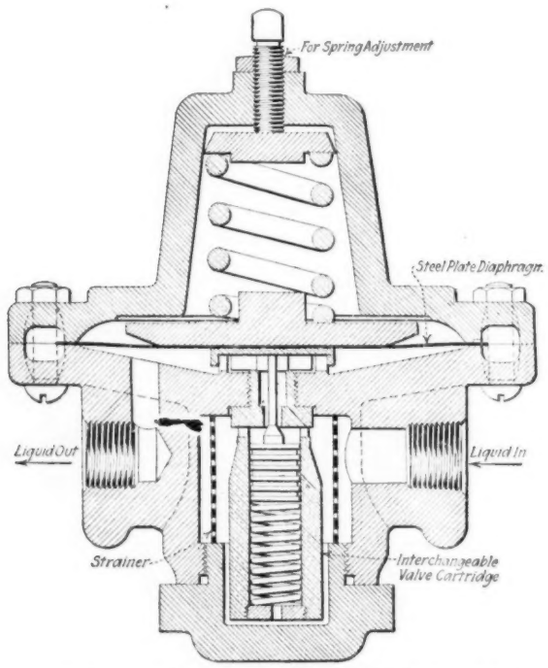


FIG. 1. AUTOMATIC EXPANSION VALVE

to provide the necessary refrigeration for cooling the brine to an amount sufficient to hold the temperature of the room during the nighttime.

Likewise, the brine-storage tank and circulating pump take space and considerable extra power. The compressor, which operates but about one-third of the total time, has to be of sufficient size to carry the day load and store up sufficient refrigeration for the night as well. Also, the operation is not so efficient, for the pumping action of the brine pump has a heating effect, which alone would heat the brine, even if no refrigeration were being done. For example, a one-horsepower centrifugal brine pump would heat the brine at about the same rate as one-fifth of a ton of refrigeration; namely, 42.4 heat units per minute would cool it.

The methods mentioned—"holdover" tanks and brine-storage tanks—are objectionable on account of the space

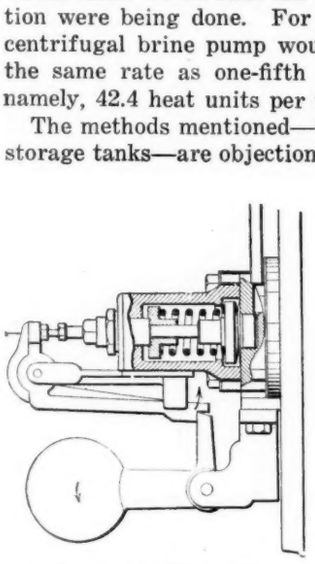


FIG. 2. NO-PRESSURE TYPE

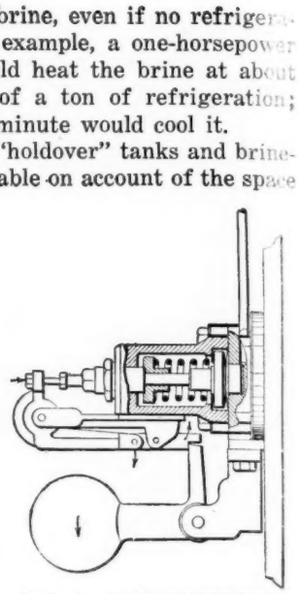


FIG. 3. EXCESSIVE-PRESSURE TYPE

Control valves operated by springs and gas pressure

occupied and the poor efficiency of operation. The compressor and high-pressure side have to be of extra size so as to provide the required tonnage in the part time of operation, including, as it does, not only the day load, but the night load as well. And therefore we have the automatic refrigerating system, which may operate without constant attention the twenty-four hours of the day, or off and on with the demand which is thermally controlled by a thermostat located in the cold-storage room. As it may operate full time, it may be of only two-thirds or one-half the size required of the other designs, which are arranged for part-time operation only. Before going into a detailed description of the totally automatic refrigerating machine, it will be advisable to review the semi-control systems.

Semi-Control Systems

The advent of the small inclosed type of compressor has been a decided advance in the art of refrigeration. It is splash-lubricated, and while the crank case remains supplied with oil, it is reasonably free from the dangers incidental to the lack of lubrication. Likewise, the main compressor bearings are ring-oiled, a method that is reasonably safe as long as the ring or chain revolves freely. There remains, then, the necessity for control of the water supply, the excess condenser-pressure control and some regulation of the expansion valve (if this last seems justified). In this connection attention is again called to the fact that if the suction pressure is too high, no refrigeration will be obtained at all, as the temperature of boiling of the ammonia at high pressures may be above the temperature desired. Likewise, if the suction pressure is too low the cooling coils will conduct heat better, but they may become choked with a

low-density gas and the capacity of the compressor will drop to one-half or one-third of the normal tonnage in consequence of this so-called high *specific volume* of the ammonia.

The Suction-Control Valve

The suction-control expansion valve is in principle like the well-known back-pressure valve except that the latter deals only with gas on both sides of the valve while the expansion valve must have liquid on one side and liquid and some 5 to 10 per cent of gas on the other. There is another difference, too, which must be given consideration; namely, that a little liquid ammonia will go a great way in producing refrigeration and the opening must be very small and the valve must be designed for close adjustment. With a head pressure of 150 lb. on one side and 15 lb. on the other it is clear that a large amount of liquid could pass through a very small opening, and a pound of liquid ammonia per minute will provide the cooling effect required of about two and a half tons of refrigeration.

A good example of such an expansion valve is shown in Fig. 1. This is a design using the diaphragm method of control. Liquid ammonia comes in on the right-hand side, as shown, and passes through the filter and then to the conical reducing valve, which has an extended stem that presses on a pusher plate. The pusher plate rests on the diaphragm, which is also under the pressure of a control spring. The under side of the diaphragm has suction pressure, and the upper has a spring pressure which is regulated by the engineer for the operating pressure desired. Such a device should give close regulation and should be capable of relieving all thought of the expansion-pipe boiling temperature from the mind of the operator.

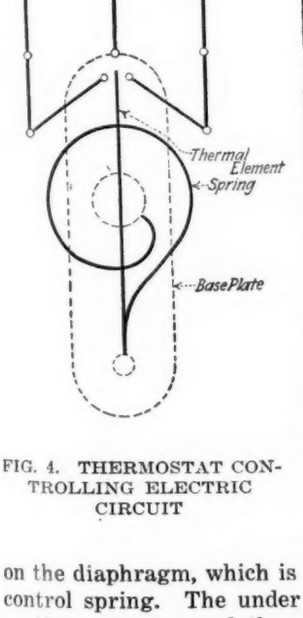


FIG. 4. THERMOSTAT CONTROLLING ELECTRIC CIRCUIT

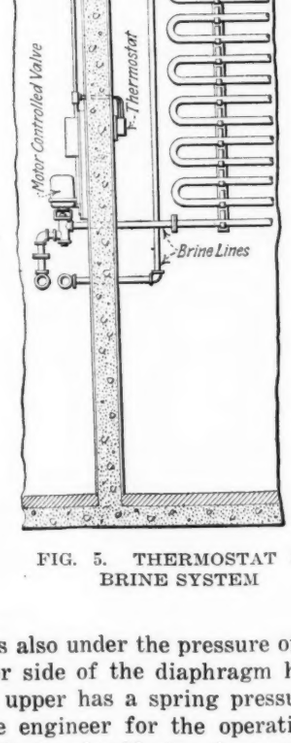


FIG. 5. THERMOSTAT ON BRINE SYSTEM

The Excess-Pressure Release

Unless the discharge valve on the compressor is closed or in some most inconceivable way the discharge line is obstructed, then a sudden increase of head pressure is caused, without exception, by the condensing water used on the condenser. If this condensing water is not turned on or is turned off, or fails to function properly, then the head pressure will rise. As the ammonia compressor is usually made with small clearances, the pressure that may be obtained under these conditions may be excessive and decidedly dangerous.

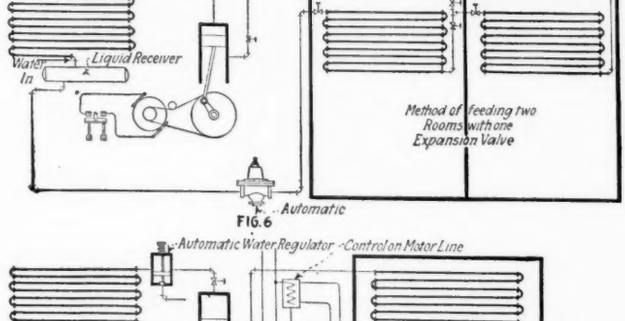


FIG. 6

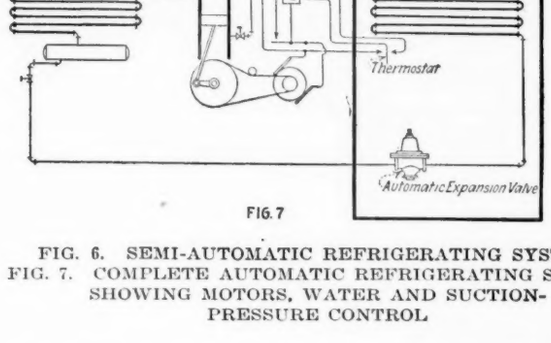


FIG. 7

FIG. 6. SEMI-AUTOMATIC REFRIGERATING SYSTEM
FIG. 7. COMPLETE AUTOMATIC REFRIGERATING SYSTEM SHOWING MOTORS, WATER AND SUCTION-PRESSURE CONTROL

The result is that some head-pressure relief must be provided in the automatic system we are now discussing.

The most elementary of these relief valves are those operating against a spring or a diaphragm and so adjusted as to give movement to a small plunger. This plunger acts on a trip which releases a trigger to which is attached a weighted cord that in falling pulls open the main electric switch (See Fig. 3). Other simple devices are on similar lines of design. The relief valve, identical to the steam-boiler safety valve, may be placed on the discharge header and piped either to the atmosphere or into the suction header. In the latter case the relief valve becomes simply a bypass valve, but loaded to a certain discharge pressure. Then again there may be a solenoid device that operates the main switch on the electric circuit. This solenoid is excited by a current that is made when the arm of the pressure gage turns to a certain desired pressure, say 225 lb., when contact is made and the electromagnet stops the motor. Likewise, a device may be used, embodying the solenoid principle with that of the safety-valve design. The lift of the valve is made to close the electric circuit, the solenoid is excited and the main switch on the motor circuit is made to open. But all of these designs operate on the head pressure and are planned for shutting down the compressor. The cooling water may always be responsible for the excessive head pressure, but it is not regulated by the controls so far described.

The simplest water regulator is one driven by the compressor itself. For the method of control it is necessary to have a pump capable of supplying the condensing water required and subject to some suitable variation of capacity by which more or less volume of water

is pumped per stroke of the piston. A variable control of amounts of water is absolutely required unless, as in some wells, the temperature is a constant. A more elaborate valve would be one *similar* to Fig. 1, which in this case would use the action of the ammonia, working under condenser pressure, underneath the diaphragm. The rise or fall of this pressure actuates a valve that regulates the amount of water permitted to pass to the condenser, more water being admitted with an increase of condenser pressure.

To resume, the semiautomatic control system (Fig. 6) is one that is designed to run under certain prescribed conditions: The suction pressure is to remain constant, the water is adjusted for normal conditions, and there is an arrangement for shutting down the machine when the head pressure becomes excessive. The machine is safe under these conditions, and while the compressor is so operated, it is possible to produce useful refrigeration.

But if the machine stops, it remains stopped until the engineer returns. Also, it will continue to operate irrespective of the cold-storage temperatures being maintained in the storage rooms. The conditions are simply those of *safe* operation during the absence of the engineer in charge. Fig. 6 shows schematically the arrangement of such a refrigerating cycle.

Complete Automatic Systems

The completely automatic refrigerating system, Fig. 7, is electrically driven, and it is so controlled as to require the minimum of attendance such as would be required to keep the plant in first-class operating condition. If necessary, it may operate the twenty-four hours, starting and stopping as required by the temperature of the cold rooms. A thermostat is located in the room containing the expansion valve, and it is the master control of the whole plant.

In general the rise of temperature of the cold-storage room expands the elements of a thermostat, in consequence of which electric contact is made and the electric motors are excited and the compressor is started. Water is pumped over the condenser by means of a directly connected pump, or the increased head pressure due to starting the compressor actuates the water valve, which opens until a certain condenser pressure is obtained. As the compressor continues pumping, the suction pressure is reduced and the expansion valve is opened, which allows liquid ammonia to pass with the expansion (refrigerating) coils. As the expansion valve is adjusted for a particular back pressure, it permits a suitable boiling temperature for the ammonia. Operation under these conditions will reduce the cold-storage temperature and the thermostat will open the circuit and the motor and compressor will stop. Subsequently, a decrease of head pressure will close the water valve (if one is used) and a rise of the boiling pressure (suction) will close the expansion valve. A diagram of such an arrangement is shown in Fig. 4.

Finally, it may be said that some part at least of the automatic devices just described will soon be in common use, especially in the large cities. Safety relief valves are now required, and it is more than likely that remote-control valves or automatic nonreturn valves on the condenser, receiver and the expansion piping will be required also. The main objection to the automatic plant is its increased first cost, but it is not unlikely that all plants will be better safeguarded in the future and the disparity in initial cost will not be so marked. The engineer should acquaint himself with these special ammonia valves, therefore, and their advantages.

Crude Petroleums and Lubricating Oils

Characteristics of Crude Petroleum; Origin; Refining; General Requirements To Be Expected from Oils in Common Use in the Power Plant

By J. D. ROBERTS

THE American petroleum industry began with the sinking of the first oil well in Pennsylvania in 1859, just two years after oil had been struck in Roumania. In February, 1916, the United States Geological Survey estimated that the then known fields in the United States were 32 per cent exhausted.

There are two well-known types of crude petroleum—paraffin-base oils containing much light oil and considerable paraffin wax, like the Pennsylvania oils, and asphalt oils, which contain little light oil or paraffin wax but much heavy low-cold-test oil, like the Texas oils. A third type recognized is the so-called "mixed-base" oil, an intermediate of the other two types. Paraffin-base oils consist largely of compounds containing relatively more hydrogen than is present in the asphalt-base or naphthalene oils.

Crude oils are valued largely on the basis of the products distilled. Oils yielding much gasoline and kerosene in simple distillation and rich in paraffin bring the highest return per unit of sale, though the amount of the sulphur impurities is of much importance.

Oils from New York, Pennsylvania, West Virginia, Kentucky and eastern Ohio are in general paraffin-base, free from asphalt or objectionable sulphur, and yield by ordinary distillation high percentages of gasoline and burning oils. Their gravity ranges from 34 to 48 deg. Baumé.

Oils from Indiana and northwestern Ohio consist chiefly of paraffin hydrocarbons, though containing some asphalt, and are contaminated with sulphur compounds requiring special treatment for removal, usually with calcium oxide of lead or copper. There are also some lubricating-oil distillates produced in this field. The oils from Canada are classified in this group.

Illinois oils are mixed-base and paraffin-base with widely varying sulphur content, which generally can be removed without special treatment.

Oils from Kansas, Oklahoma, northern and central Texas and northern Louisiana vary in composition from asphaltic oils low in gasoline and kerosene to paraffin oils with good yields of gasoline and kerosene. The sulphur present varies in quantity and in some cases requires special treatment for its removal.

Oils from the Coast Plain of Texas and Louisiana are high in asphalt and low in gasoline. Much of the sulphur content is in the form of sulphureted hydrogen and is removable by steaming.

Wyoming and Colorado oils are mainly paraffin-base,

though some asphaltic-base oil is found in Wyoming. Oils from California are generally asphalt-base, yielding no paraffin and with extremely variable sulphur content. Fire oils, kerosene, lubricants, oil asphalt with a slight yield of gasoline are manufactured from these crude petroleums; their gravity ranges from 12 to 30 deg. Baumé.

Oils from the Mexican fields are similar to the oils from the Coast Plain of Texas and southern Louisiana. They contain excessive sulphur compounds and are low in gravity, 14 to 19 deg. Baumé.

In the order of their gravity, 34 to 48 deg. Bé., the light oils may be classified as Pennsylvania, Illinois, Louisiana, Kansas, and Oklahoma.

Among the heavy oils, 1 to 30 deg. Bé., are the Gulf Fields (southern Texas and Louisiana), Mexico and most California fields.

Crude Mineral Oils a Mixture of Hydrocarbons

Crude mineral oils are made up chiefly of a mixture of compounds generally classified as hydrocarbons having a composition of from 12 to 14 per cent hydrogen and 84 to 88 per cent carbon. From the light hydrocarbons like methane (CH_4) and ethane (C_2H_6) found in natural gas to the heavy solid bodies like paraffin or asphalt and the viscous oils which cannot be distilled without decomposition, these hydrocarbons vary widely in boiling point. As a general rule paraffin hydrocarbons have a low lubricating value. It is also a fact that the viscosity of hydrocarbons increases rapidly with the increase in molecular weight, so if high-viscosity products are to be made from crude oils of the paraffin-base class, distillation must be conducted with as little decomposition as possible. The separation of the individual compounds from petroleum is practically impossible on account of the boiling points of the compounds being modified by the presence of the other hydrocarbons in the mixture. The production of gasoline, kerosene and various lubricating oils is made by separation into groups of compounds with certain boiling limits.

Hydrocarbon will resist chemical action to a marked degree, and thus petroleum oils show little tendency to attack metals. Animal and vegetable oils show considerable tendency to form acid and will readily attack some metals.

Theories of Origin

Since different petroleums have different compositions, there is naturally a great variety of theories to account for its origin. The inorganic theories depend largely on the action of water on heated metallic carbides, somewhat as acetylene is produced commercially. Some authorities claim that the theories which are most in accord with the facts are those of organic origin from the decomposition of animal and vegetable remains. Oils from some Texas fields show evidence of marine animal origin. Also the considerable percentage of nitrogen compounds present in some oils would seem to indicate animal origin. It is a fact that some of the original differences in petroleum have been further modified by the migration of the oil and its filtration through different strata, which changes the composition of the oil.

The manufacture of lubricating oils and other products from the crude petroleum is accomplished by distillation and chemical treatment. Distillation separates the hydrocarbons into groups of different boiling points. Where heat is applied, the crude petroleum becomes more fluid by the melting of certain substances in the petroleum, or in other words, decreasing the cohesion of the liquid particles. As the temperature is raised, some of the crude petroleum will evaporate, and this, when condensed, will yield gasoline, kerosene and other light distillates. While the process is carried out, some of the hydrocarbons will be decomposed or "cracked" by the heating; from this stage come products of lower boiling point than those present in the original petroleum. With proper control of the heating and prevention of overheating, the best lubricating products are obtained when the least amount of decomposition and cracking of the original compounds of the crude petroleum takes place. There are two general methods of distilling; namely, fire and steam distillation. From the standpoint of lubrication the best oils are made by steam distillation, and steam cylinder oils cannot be made in any other way.

Steam Distillation of Crude Petroleum

Briefly, the steam distillation method is carried out as follows: The stills are cylindrical steel tanks supported in brick settings. Heat is first applied by direct fire, and as soon as heating has begun, steam is forced in by means of perforated pipes extending to the bottom of the still. This steam stirs the oil and prevents local overheating, and at the same time escaping steam vapors carry off the oil vapors as soon as formed, so that they do not condense and fall back into the still. These oil vapors pass out through large-diameter pipes at the dome of the still to a vertical tower condenser. In this condenser the heavy oils condense first near the bottom and the light oils condense last near the top. Thus with this type of condenser the oil may be separated into groups during the first distillation. With other types of condenser the distillates may have to be redistilled for this separation into groups. The groups so collected are, in the order of their boiling points: Crude naphthas, illuminating oils, gas oils, light lubricating distillates, heavy lubricating distillates and undistilled residue.

The distillation is usually stopped just before 600 deg. F. The residue distilled is suitable for light stock, if Pennsylvania or other paraffin-base stock has been used. The various distillates are distilled to rid them of light and heavy ends and render the removal of paraffin from the lubricating distillates less difficult. The use of steam not only gives better grades of lubricants but increases the yield of lubricating oils as well, particularly of cylinder stock.

Redistillation of Lubricating Oils

Lubricating-oil distillates are distilled the second time by fire or steam. By the addition of steam the undistilled residue goes into fuel oil. The oils are chilled and filter-pressed to remove paraffin wax. They may be partly distilled again and reduced, to remove the light oils and so raise the viscosity. The light oils distilled in this reducing process may be run into the gas-oil distillate or made into thin lubricating oils, called "non-viscous neutrals." The reduced lubricating oils are filtered through fuller's earth or boneblack to improve the color and remove impurities and are then ready for use as "viscous neutrals."

The residue in the still, if a paraffin-base crude has been used, is a steam-refined cylinder stock. If the temperature has been carried well above 600 deg. F. dur-

ing the distillation, most of the paraffin has been distilled off. To make a filtered cylinder stock, the residue is "cut back" with crude naphtha, chilled and filter-pressed or otherwise filtered, and the gasoline finally recovered. The product is a filtered, low-cold-test cylinder stock.

The so-called Western lubricating oils are made from crudes that contain little paraffin. The procedure is similar to the refining of Pennsylvania oils, except as it may be modified by the character of the merchantable products possible. Most of the California crudes and much of the Oklahoma and Texas crudes are "topped" for the removal of gasoline and illuminating oils, and the undistilled residue is sold direct as fuel oil without further refining.

Oklahoma crude and some heavy crudes from Texas and California are now worked up for the manufacture of certain lubricants, such as cylinder oil, red engine oil and lighter lubricating distillates. The distillates have higher gravities, lower flash points, higher viscosities at low temperatures (70 or 100 deg. F.) and lower cold tests than do Pennsylvania products of the same class.

Characteristics and Requirements of Oils Commonly Used in Power Plants

In the following are given the characteristics and general requirements to be expected from gas oil and oils in common use in the power plant:

Gas Oil—The oils distilled between illuminating oils and the light lubricating oils are used for carbureting water gas and other gas to improve the illuminating power and for the direct manufacture of gas in heating retorts as applied in the production of illuminating gas direct from the oil. This gas oil is a cheap product. In redistilling the lubricating-oil distillates, the light ends are run into the gas oil. This product is sometimes used for fuel oil. Its gravity generally ranges from 32 to 38 deg. Baumé.

Neutral Oils—These oils are manufactured by steam distillation and are of high viscosity in proportion to their gravity. After the wax has been removed from the mixed lubricating-oil distillate, the oil is "reduced" by steam distillation to remove the lighter oils. These light oils constitute the nonviscous neutrals, while the residue from this final distillation constitutes the viscous neutrals.

The nonviscous neutrals usually have a gravity well above 30 deg. Bé. and a low viscosity suitable for light spindles. These oils are considered the best spindle oils as they do not stain like paraffin oils. They are not usually acid treated. The viscosity is 45 to 65 at 100 deg. Fahrenheit.

The viscous neutrals are usually slightly above 30 deg. Bé. and have viscosities ranging from 80 to 200 at 100 deg. F. They are suitable for motor oils, turbine oils, gas-engine oils, air-compressor oils and for the highest grade of service. The color is reduced by repeated filtration through fuller's earth instead of by acid treatment. To make the heavier oils, the viscous neutrals are blended with small amounts of high-flash, filtered, steam-cylinder stock. Blended oils of high viscosity may have gravities as low as 27 deg. Bé., even when from Pennsylvania stock. Viscous neutrals are also made from other stocks, in which case the gravities will be much lower than from the Pennsylvania distillates alone.

Spindle Oils—These are low-viscosity oils of 45 to 100 Saybolt at 100 deg. F. They may be light paraffin oils, but usually and preferably they are the nonviscous neutrals.

Engine Oils—Commercial engine oils are usually the heavier paraffin oils. The heavier oils are nearly always red, but the amount of color depends on the amount of acid treatment or of filtration. The color is not an index to the lubricating quality. Heavier engine oils are sometimes built up by the addition of cylinder stocks to heavy distillates. Viscous neutrals were formerly much used as engine oils. Under present-day manufacturing conditions, high-gravity neutrals now go largely into the motor-oil trade. At the same time low crude Western neutrals are sold to a large extent as engine oils. For circulating systems neutral oils are to be desired and are more satisfactory than paraffin oils, as they separate from water more readily.

Turbine Oils—These are similar to the lighter motor oils. The neutral oils separate from water better than do the paraffin oils and are naturally more desirable for this class of service.

Air Compressor Oils—These are similar to the lighter motor oils.

There is also a class of undistilled oils, from which, by steam distillation of Pennsylvania oils or other paraffin-base oils, a heavy undistilled oily residue is left in the still. This is used as a cylinder stock after being removed from the impurities. It generally has a high fire test of 500 deg. F. and a viscosity, when from Pennsylvania stock, of 140 to 280 at 210 deg. F. The gravity of such stock will not run below 24 deg. Baumé.

Under this class there is a filtered cylinder stock having a fire test that rarely runs over 600 deg. F. and a viscosity that seldom exceeds 160 and gravity not less than 26 deg. Bé., if made from Pennslyvania stock. As a general rule in the manufacturing of oils, filtering is considered to reduce the viscosity of cylinder stock. Bright stocks generally show a low cold test. Compounded oils are made by mixing or blending a mineral oil with a fatty oil. The chief compounded oils are cylinder oils made by dissolving animal oil or other animal fats in cylinder stock. Marine-engine oils are made by dissolving rape oil or blown rape oil in mineral oil. Compounded oils for other purposes than steam-cylinder lubrication are seldom used. As a general rule the viscosity of a compound oil is much less than the theoretical viscosity calculated from the oils used.

Experiments are to be undertaken at the Arlington (Va.) experimental farm of the United States Department of Agriculture by the chemists of the Bureau of Chemistry on the production of gas by the distillation of straw, corn stalks, leaves, etc. The work will follow the lines of the investigations made at the University of Saskatchewan for several years. The plant consists of a single retort with accessory cooling, washing, and gas-storage equipment, which will permit tests of various sorts of materials under different conditions of distillation. The methods best suited to the use of the gases for farm-power production will also be studied. The amount of work that can be done during the coming year will depend largely upon the amount of the general appropriation for the Bureau of Chemistry, as no special funds for this particular work are available as yet.

Some Characteristics of Shaft Governors

By Charles Myers

Among the many questions concerning shaft governors, with curved slot eccentrics, that are of interest to the engineer, the following are the most prominent: Does the action of the governor, in changing from full load to no load cause the eccentric to revolve around the shaft, or to move across the shaft? Does the action of the governor change the lead in any way, or will the engine maintain the same lead under different loads? If the engine increases its speed a few revolutions per minute when the load is decreased, will the action of the governor cause the exhaust port to close earlier and provide the extra compression needed for the increase in speed? In answer to the first question, it can be seen from Fig. 1 that the eccentric does not revolve around the shaft, but that it moves across the shaft, describing a short circular arc about a center, which is some distance from the center of the shaft. The pivot about which the eccentric swings is usually on a spoke of the flywheel.

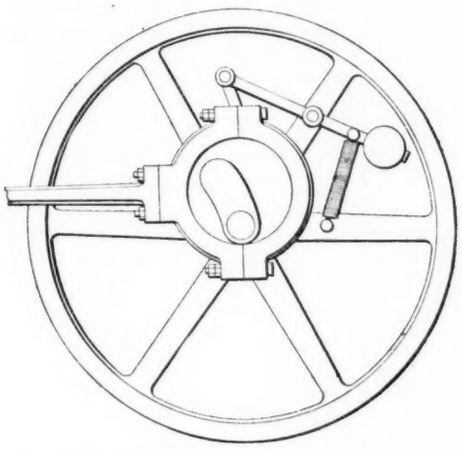


FIG. 1. CURVED SLOT ECCENTRIC FOR SHAFT GOVERNOR

In most engines the lead will remain very nearly constant under all loads on one center, but will vary a little more on the other center. The amount and direction of these variations will depend on the position of the eccentric pivot and on the length of eccentric rod.

In Fig. 2 is shown the position of the eccentric under full load with the engine on the crank-end center and the valve (a piston valve) showing a certain amount of lead at *A*. Now, assuming that the eccentric is not fastened to the flywheel in any way, it is free to move across the shaft and will move in a circular arc about a center at the joint between the valve rod and the eccentric rod. Under these conditions the valve would not move as the eccentric swings across the shaft. Now, if the eccentric is moved across the shaft after being attached to the flywheel, it will not describe the same arc as when the joint in the valve steam served as the center, and the valve will move from its original position, thereby changing the lead.

The relative changes may be better understood by referring to Fig. 3. The arc *H* is drawn about a center at the point *X* and represents the path of the center of the eccentric if it turned about the joint at the end of the valve rod. The arc *R* was drawn about a center at the point *Y* and represents the path of the eccentric when swinging about its regular pivot on one of the flywheel spokes. In the case illustrated the line through *X* and *Y* represents the center line of the engine, and the distance between the points where the two arcs intercept this line would represent the movement of the valve and therefore the change in lead, in going from the full-load position to the no-load or neutral position. Referring back to Fig. 2, it is obvious that under these conditions as the load decreased the valve would be moved toward the crank end, and therefore the lead would be increased.

When the engine is on the head-end center, the position of the eccentric and valve will be as shown in Fig. 4. Referring again to Fig. 3, the arc *K* represents the path of the eccentric in swinging across the shaft about the valve-rod joint (center at *a*) and the arc *S* the path when the eccentric swings about its fulcrum (central at *b*). As before, the distance between these two arcs, when measured along the center line of the engine, will present the change in lead, and it is obvious that this change is greater than in the case where the engine was on the crank-end dead point. In drawing the diagram in Fig. 3, the proportions were so taken as to exaggerate the change in lead so that it might be seen easily. In the actual engine the length of the eccentric rod is so great in proportion to the distance through which the eccentric swings that the arcs *H* and *K* are, for all practical purposes, straight lines at right angles to the center line of the engine. Under these conditions the difference between the change in lead on the two ends is too small to be measured, and although there is such a difference it would not show up on the indicator card in the case of any reasonably well-designed engine. It is also true

FIG. 2. POSITION OF ECCENTRIC AND PISTON VALVE AT FULL-LOAD; ENGINE ON CRANK-END CENTER

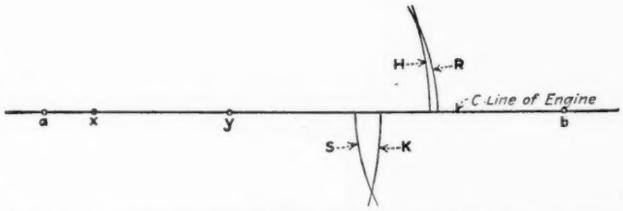


FIG. 3. DIAGRAM TO SHOW CHANGE IN LEAD AS THE ECCENTRIC SWINGS ACROSS THE SHAFT

FIG. 4. POSITION OF ECCENTRIC AND PISTON VALVE AT FULL-LOAD, ENGINE ON HEAD-END CENTER

that in an actual engine the total swing of the eccentric is relatively much smaller and the radius of the arcs R and S is relatively much greater than is shown in Fig. 3. As a result, the change in lead becomes very small and is usually considered negligible.

In the case illustrated, the pivot about which the eccentric swings is located 180 deg. from the crank, and the valve is a piston valve taking steam at the middle. Under these conditions, as the eccentric swings across the crank the lead is increased. If the eccentric pivot were placed in line with the crank and used in connection with a piston valve, the effect would be to decrease the lead. This can be seen by referring again to Fig. 3, where, under these conditions, the arc R would be curved in the opposite direction, which would result in moving the valve toward the head end of the cylinder, and this, as will be seen from Fig. 2, would result in closing the port and therefore decreasing the lead. With a plain slide valve, and the eccentric pivot in line with the crank, moving the valve toward the head end when the engine is on the crank-end center would result, of course, in an increased lead. In the fourth possible case the pivot of the eccentric is 180 deg. from the crank, with a plain slide valve, which will result in an increased lead as the eccentric moves across the shaft.

The most important feature of the governor is its ability to change the point of cutoff so as to admit just the amount of steam required to maintain a uniform speed under any load. In order to do this it is necessary to make cutoff come earlier when the load decreases or the speed increases. Referring again to Fig. 1, the eccentric is here shown as it would be with the engine standing still; that is, the spring has drawn the eccentric out as far as possible. In this position, which is also shown in Fig. 2, the "thick part" of the eccentric is along the line ab, and as the engine runs over, the valve will continue to open until the point b turns into line with the center line of the engine. From that time on the valve will be closing, although, of course, cutoff will not occur until some time later. Suppose now, that the weight is pulled out by centrifugal force, when it will be seen from Fig. 1 that the eccentric will move down across the shaft. Referring again to Fig. 2, this will result in the thick part of the eccentric being along the line DE, which is already practically on the center line of the engine, and therefore the eccentric is in a position to begin closing the port. It is obvious, then, that as the weight on the governor moves out, steam will be cut off earlier.

A study of the valves and ports, as shown in Fig. 2, makes it clear that an earlier cutoff simply means that the valve has reached a certain point in its travel somewhat earlier. If, then, the steam port on the crank end is closed earlier, obviously the exhaust port on the head end must be closed earlier, since both are closed as the valve moves toward the head end of the cylinder. It is evident, then, that the curved slot eccentric will give the desired earlier compression, as the load on the engine decreases.

The usual method of explaining the ability of the governor to produce an earlier cutoff and an earlier compression is to say that as the weights fly out the angular advance of the eccentric is incraesed, and its eccentricity is decreased. It is hoped that the explanations given here, which are in an entirely different form, will make this matter plain to some who have difficulty in understanding the more technical form.

Wattmeter and Power-Factor Indicator Connections

By H. C. Yeaton

Figs. 1 and 2 show the connections for a polyphase wattmeter and power-factor indicator to measure the power and power factor of a three-wire, three-phase circuit, using either two or three current transformers,

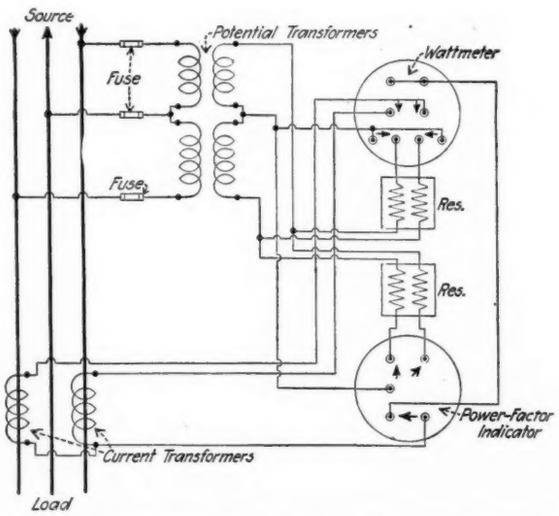


FIG. 1. WATTMETER AND POWER-FACTOR INDICATOR CONNECTIONS WITH TWO CURRENT TRANSFORMERS

and two potential transformers. The use of three current transformers, in the installation of instruments in power plants, quite frequently occurs. However, only two current transformers are necessary to give the same results.

It is preferable to connect the instruments like Fig. 1, as it eliminates the cost and installation of an extra

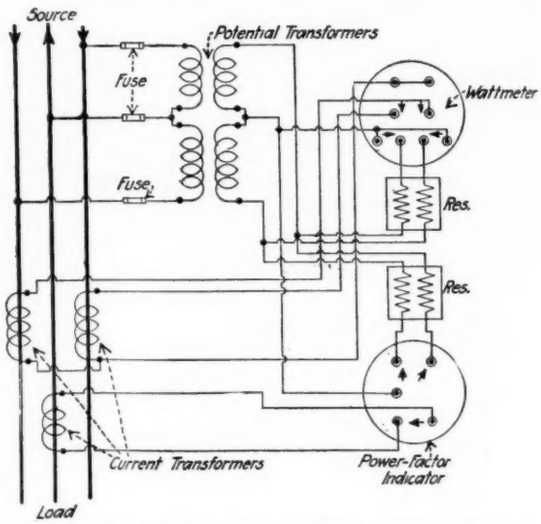


FIG. 2. WATTMETER AND POWER-FACTOR INDICATOR CONNECTIONS WITH THREE CURRENT TRANSFORMERS

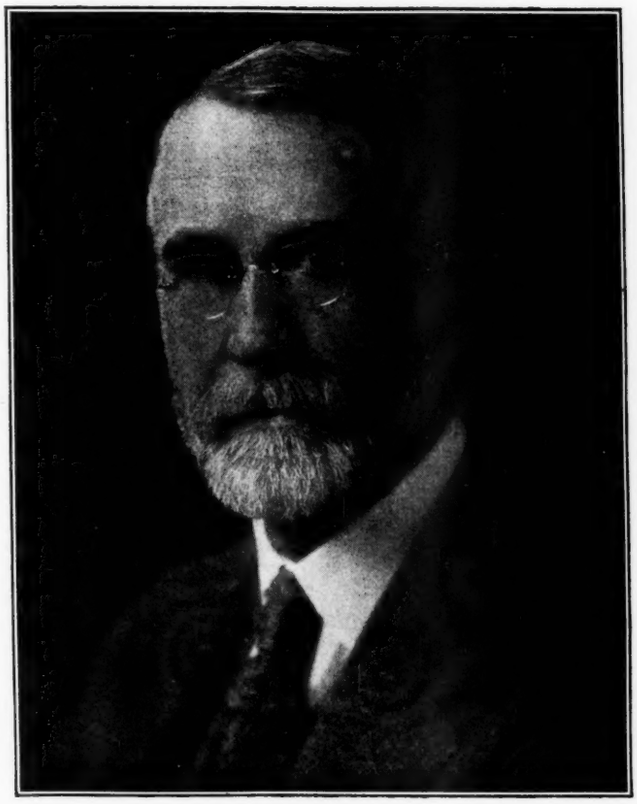
current transformer. The same results are obtained by either method of connections, as the resultant of the two current transformers in Fig. 1 is the same as that of the extra current transformer in Fig. 2, and the instantaneous polarity of current through the instrument is the same in both cases, as is indicated by arrows.

Charles T. Main—Industrial Engineer

A Technical Man with Wide Experience in This Newly Recognized Field of Engineering

AMONG the suggestions contained in a recent committee report to the American Society of Mechanical Engineers was a recommendation that Industrial Engineering be considered as a major subject in arranging for discussions by the Society. This is only one testimony to the growing recognition of the importance of this branch of engineering.

The problems of power generation and use, of the uses of steam in various manufacturing processes, of the complicated automatic machinery in the modern factory and most important of all, the human or social problems involved where large numbers of people work together must be solved, not as individual problems but with regard to their relations to each other. It is the industrial engineer to whom we must look to solve these problems and on whose solution of them depends the success or failure of modern industry in this country. It has been said that America could always produce the right man or men to fill any need. When the need for industrial engineers was recognized it was found that a group of men were already at work fulfilling the need. One of the men occupying a prominent position in this group is Charles T. Main of Boston. His engineering experience has covered textile mills, industrial plants of all kinds and steam and hydraulic power development. He has had a hand in the evolution of a number of large enterprises and has contributed no small amount to the general industrial progress.



CHARLES T. MAIN

Mr. Main was born in Marblehead, Mass., Feb. 16, 1856, and can trace his ancestry to old American families established in colonial days. He graduated from the Massachusetts Institute of Technology in 1876 with the Degree of Bachelor of Science in the Department of Mechanical Engineering and spent the next three years as an assistant in the same department. It is a familiar saying among teachers that the best way to learn a subject thoroughly is to teach it to someone else. Undoubtedly Mr. Main's three years as a teacher served to round out and fix in his mind the technical training he had received while a student.

In 1879 he began his connection with industry as a draftsman in the Manchester Mills, Manchester, N. H., leaving there in January, 1881, to become engineer of the Lower Pacific Mills in Lawrence, Mass. In 1886 he was promoted to the position of assistant superintendent, and a year later became superintendent of the mill. From the first of his connection with the Pacific Mills Mr. Main's duties required considerable executive ability and gave him a chance to show what he could do. That he was at heart an engineer, rather than an executive is shown by his action in retaining direct control of all engineering work when assuming the executive duties of the superintendency. During his eleven years with this mill he directed the reorganization and rebuilding of the plant and for more than five years had charge of its operation. Finally the "call of engineering" became too strong to be resisted and in 1892 he left the Pacific Mills and began the practice of miscellaneous engineering work in Providence. In January, 1893, he became associated with F. W. Dean under the firm name of Dean & Main in general engineering work. As was natural, the attention of the new firm at first was devoted to textile engineering, but gradually it reached out to include work in every sort of industrial plant. In 1907 Mr. Main embarked independently under the name of Charles T. Main, Engineer.

During his seventeen years as an industrial engineer, Mr. Main's services have been in demand over the entire field of such engineering. He has directed the design and construction of many plants and has reorganized others. Among his larger undertakings are the Wood Worsted and the Ayer Mills in Lawrence as representatives of the textile industry, and developments for the Montana Power Company aggregating about 250,000 hp., in the hydro-electric field. In addition to his work in design, construction and reorganization, Mr. Main has served as expert witness, or as referee, in important legal actions involving engineering questions, and has made numerous appraisals of industrial plants.

He has always taken an active interest in public affairs and been ready to do what he could for the public welfare. In Lawrence he was a member of the board of trustees of the public library and a member of the school committee, besides being an alderman of the city. In Winchester where he has lived for some years he has been a member of the water and sewer board.

Mr. Main has always been active in the work of the American Society of Mechanical Engineers of which he became a member in 1885. He was a manager of the Society from 1914 to 1917 and its president in 1918. He also represented the Society in the delegation of American engineers who went to France, on the invitation of the French engineering societies, to discuss the problems involved in the rehabilitation of that country.

While naturally the American Society of Mechanical Engineer claims Mr. Main's first attention, he is also connected with other technical societies. Among them are the American Society of Civil Engineers, the American Institute of Consulting Engineers and the Boston Society of Civil Engineers. Of the last named society Mr. Main is a past president. He is also a past president of the Engineers Club of Boston and a member of the Exchange Club of Boston, the Engineers Club of New York and the Calumet and Winchester Country Club of Winchester, Mass. His financial activities include directorship in the Massachusetts Trust Co., the Tennessee Eastern Electric Co. and the Berkshire Cotton Manufacturing Co., as well as a trusteeship in the Winchester Savings Bank.

Among all his varied activities, an important, if not the most important, one is his life membership in the Corporation of the Massachusetts Institute of Technology. Mr. Main has not forgotten the institution in which he received his early training and takes an especial interest in his own department. It is true that a man of his ability would have probably succeeded without such training as he received at Technology, but undoubtedly this training has smoothed many a difficulty and helped him out of many a tight place. He has, however, well repaid his debt to the Institute by his service as a member of its governing body.

Some Notes on the Loss of Head Due to Friction in Water Pipes

By H. M. Brayton

In any system of piping through which water is pumped, the loss in head due to friction is an important item in the selection and operation of the pumping equipment. While this loss may be decreased by increased pipe sizes, an economic balance must be maintained between the saving in friction and the cost of pipe. Although much remains to be done, a great deal of experimental work has already furnished data from which we may calculate these losses with sufficient accuracy for practical purposes. These investigations also suggest methods of reducing friction losses without increasing the cost of installation.

As a guide in designing piping systems so as to balance first cost against friction losses, a velocity of not over five feet per second has been found to give reasonable results, although in some cases three feet per second is enough. As a check on this it is good practice to provide for a maximum loss of head of about five feet in one hundred feet length of pipe. The whole system should be as free from bends as possible, especially short-radius elbows. The loss in the 90-deg. bend in a 20-in. pipe is equivalent to that in one hundred feet of straight pipe.

Usually, a certain pressure is desired at the discharge end of the pipe, and adding the loss of head due to friction to the static head gives the total head on the pump. In such a determination the loss of head in the suction side of the system must not be neglected. When the pump is above the water supply, the suction friction and static heads must be added to the discharge friction and static heads in order to get the total head and required power. If the pump is below the water level in the supply, the suction friction head only is added to the discharge head and the suction static head is then subtracted to obtain the total head. In other words, when water flows to the pump by gravity, the suction head helps out and reduces the required power.

One way to determine the friction loss in the system is to obtain a table from any of the numerous pump manufacturers. These tables usually give the friction loss at the various velocities and for all of the common sizes of pipe. In the absence of such a table the loss can be obtained from the fundamental formula for friction in pipes which reads as follows:

$$H = \frac{fLV^2}{2gD}$$

in which H = lost head in feet; L = length of pipe in feet; V = velocity of water in pipe in feet per second; D = pipe diameter in inches; f = the friction factor; $g = 32.2$.

The value of f varies slightly for different velocities and for different diameters of pipe. For the usual range met with in power-plant practice, however, a value of 0.025 is accurate enough for practical work. The equation then becomes

$$H = \frac{0.025\,LV^2}{64.4D}$$

If $L = 100$ ft., the formula simplifies to

$$H = \frac{0.025 \times 100V^2}{64.4D} = \frac{0.0388V^2}{D}$$

Elbows and bends are transferred into equivalent feet of straight pipe in calculating the losses.

In the determination of the lost head in systems that are made up of several branches extending from one, it must be noted that the sum of the losses in the different branches is not the lost head for the system. This would be a much larger value than the true one. The branch that contains the longest line or has the largest number of elbows should be selected and its lost head determined. It is sometimes necessary to calculate all the branches in order to tell which one has the greatest loss. When this is found, it should be added to the loss incurred in the system up to the point where that branch leaves the header. This total will be the maximum loss for the system.

When the delivery point is located a long distance from the pumphouse, the friction loss may be considerable, and the designer must look for ways and means of reducing it to a minimum. It sometimes happens that two or more lines are run, each fed by its own pump. This arrangement is all right when the distance is short, but when long the loss is much more than nec-

essary. In this connection it is interesting to note how the friction loss is reduced in such a case by merely combining the several pipes into one large main. Not only is friction head reduced by this procedure, but considerable saving in first cost is realized. A general formula showing just how the friction does decrease as we combine several pipes into one, may be deduced, using the following notation: h = head lost in each small pipe in feet; H = head lost in the one large pipe in feet; d = diameter of small pipes in inches; D = diameter of large pipe in inches; f = friction factor = 0.025; L = length of pipe in feet; V = velocity of water in feet per second.

The size for the one large pipe should be such that the velocity of the water through it shall be the same as in the several small pipes. The fundamental friction formula already given may be written,

$$h = \frac{f L V^2}{64.4\, d} \text{ and } H = \frac{f L V^2}{64.4 D}$$

As the quantity of water flowing is always equal to the area multiplied by the velocity, and assuming equal velocities in the two cases,

$$Q = AV = NaV$$

where A and a are the areas of the large and small pipes, respectively. We may solve this as follows:

$$A = Na \text{ or } \frac{0.785 D^2}{144} = \frac{N 0.785 d^2}{144} \text{ or } D = \sqrt{N}\, d$$

Substituting this value of D into the H equation given above results in the following expression:

$$H = \frac{f L V^2}{64.4 \sqrt{N}\, d}$$

or solving for d, we have,

$$d = \frac{f L V^2}{64.4 \sqrt{N}\, H}$$

From the first equation under this consideration,

$$d = \frac{f L V^2}{64.4 h}$$

Now equating these two values for d gives

$$\frac{f L V^2}{64.4 h} = \frac{f L V^2}{64.4 \sqrt{N} H}$$

Assuming the value of f to be the same under the two conditions, the foregoing simplifies to

$$H = \frac{h}{\sqrt{N}}$$

This last equation tells simply that the lost head when several small pipes are replaced by one large one is equal to the lost head in one of the small pipes divided by the square root of the number of small pipes thus united. For example, if four small pipes are replaced by one large one so that the velocity of the water through the large pipe will be the same, and the total friction loss in one of the small pipe lines was 15 ft., then the loss in the one large line would be only,

$$\frac{15}{\sqrt{4}} = 7.5\, ft.$$

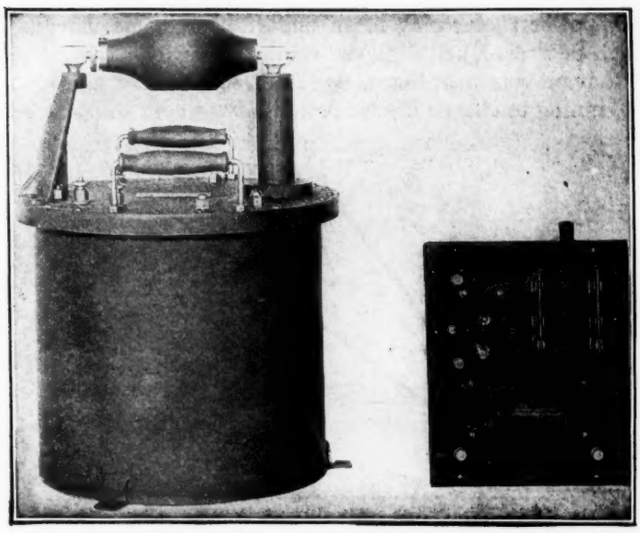
It has already been stated that the friction factor f was considered equal in the two cases, and there may be some who object to this assumption. By consulting a table of friction values, however, it will be noticed that they are smaller for the larger sizes of pipe. If f equals the friction factor in the small pipe and F that in the larger, the foregoing equation would become

$$H = \frac{F}{f} \frac{h}{\sqrt{N}}$$

As the value of f is greater than the value of F, the ratio $\frac{F}{f}$ is less than unity, which makes the value of H still smaller than when the friction factors were assumed equal.

Portable Insulating-Oil Testing Set

A small, compact, portable testing set, shown in the figure, suitable for oil testing only, consisting of a main testing transformer having a high-potential winding for 25,000 volts, a control and an oil-testing spark gap, has recently been developed by the General Electric Co. The testing transformer has a ratio of 110 to 25,000 volts and is of the oil-insulated type. The transformer weighs about seventy pounds and is equipped with handles which make it easy to carry. It is designed for indoor



OIL-TESTING TRANSFORMER AND CONTROL PANEL

service; if used outdoors, it should be provided with a suitable cover.

The control consists of an air-cooled auto-transformer with regulating taps connected to a selector switch with dial to give 15,000, 17,500, 22,500 and 25,000 volts on the high-tension winding of the main transformer, and a double-pole step-resistance knife switch, which prevents wave distortion when the transformer is cut into the line. These devices are all mounted as a unit, shown to the right in the figure.

The oil-testing spark gap is made of a hard-rubber body molded in one piece, the electrodes being one-inch disks with their shafts shrunk into the molded part. One electrode is made movable by rotating, and a gage is provided for adjusting the spacing. The test is carried out as follows: The gap is lifted from its supports and filled with a sample of the oil. It is then replaced on the supports, and after the dial on the control has been set for 15,000 volts, the knife switch is closed and held for about five seconds. If the oil does not break down, the test is repeated on higher-voltage steps.

Unity Power-Factor Synchronous Motor

By W. T. BERKSHIRE
Alternating-Current Engineering Department, General Electric Company

Examples are worked out to show how a 1,000-kw. synchronous motor affects the total kilovolt-ampere load on a system when the motor is operating at unity power factor, 0.80 power-factor leading and at 0.0 power-factor leading. The power factor of a unity power-factor motor under different loads is also discussed.

THE disadvantages of low power factor are generally known to most users of electric power. Low power factor means unnecessarily large and more expensive generators, and exciters with poor efficiency due to increased losses; increased cost of station, transforming and switching equipment and increased cost of transmission line and distributing transformers. It also results in poor voltage regulation. Furthermore, low power factor may mean underloaded prime movers with decreased prime-mover efficiency. Because of the disadvantages mentioned, power companies are already beginning to charge higher power rates where the power

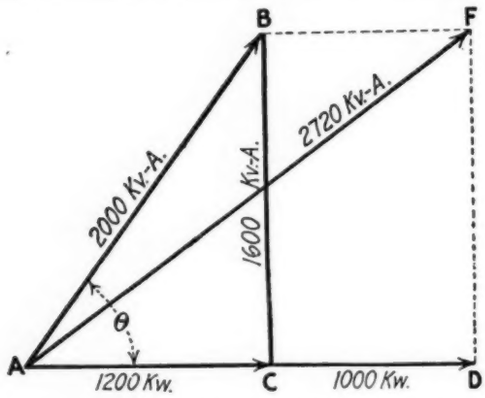


FIG. 1. EFFECT OF ADDING 1,000-KW. LOAD TO A 2,000-KVA. 0.60 POWER FACTOR LOAD

factor of the consumer's circuit is lower than a certain limit; consequently, low power factor means increased motor-operating costs.

Low power factor is due to the lagging current drawn from the line by inductive loads such as induction motors, series and multiple arc lamps or even transformers supplying incandescent lamps.

For any given mechanical load on a synchronous motor the current in the armature is a minimum at a certain field excitation, this current being neither lagging nor leading, and the motor constitutes a unity power-factor load on the line. In this case all the current taken by the motor is energy current, the function of which is to drive the load and supply the losses of the motor. Now, if the field excitation is increased, the motor will take a leading current from the line. This leading current may be separated into two components: First, an energy component as mentioned in the foregoing, and second, a magnetizing current which is a current that tends to magnetize the generator's fields, which is the so-called wattless leading component. This wattless leading component of the synchronous motor may be used to neutralize an equal amount of wattless lagging component due to induction-motor load on the system. The excitation may be further increased until the motor current consists almost wholly of the wattless leading component, the energy component being only sufficient to supply the losses of the motor, none being available for driving mechanical load. The motor is then operating purely as a synchronous condenser.

Improvement in power factor can, therefore, be effected by the application of the synchronous machine in either one of three ways: (a) As a unity power-factor motor, that is, all the input being used for energy; (b) as a power-factor correcting motor, that is, part of the input being used for energy and part for furnishing wattless leading current to the line; (c) as a synchronous condenser, that is, all the input being used to supply wattless leading current to the line. The following are examples of each of the foregoing uses:

Assume a load of 1,200 kw. at 0.6 power factor or 2,000 kva. What will be the effect of adding a 1,000-kva. synchronous motor to the system (a) at unity power factor, (b) at 0.80 leading power factor, and (c) at 0.0 leading power factor—in other words, as a synchronous condenser?

(a) As a Unity Power-Factor Motor—Referring to Fig. 1, the initial load, 1,200 kw. at 0.60 power factor, is represented by the line AC, the kilovolt-amperes being $\frac{1,200}{0.60} = 2,000$, represented by the line AB. The wattless lagging kilovolt-amperes, represented by $BC = \sqrt{AB^2 - AC^2} = \sqrt{2,000^2 - 1,200^2} = 1,600$ kilovolt-amperes. Now, by adding a 1,000-kva., 1.0 power factor load, represented by the line CD, the total load becomes $AC + CD = AD$ or, $1,200 + 1,000 = 2,200$ kw. The wattless lagging kilovolt-amperes remain unchanged, or 1,600 kva. $= BC = DF$. The total kilovolt-amperes required, therefore, to deliver 2,200-kva. energy load will be $\sqrt{AD^2 + DF^2} = \sqrt{2,200^2 + 1,600^2} = 2,720$ kva., and the new power factor will be $\frac{2,200}{2,720} = 0.81$.

With the addition of this unity power-factor motor it will be noted that two important things are accomplished; namely, the power factor is raised from 0.60 to 0.81 and the energy load has been increased from 1,200 to 2,200 kw., or 83⅓ per cent, with an increase of only 36 per cent in the generator capacity; namely, from 2,000 to 2,720 kilovolt-amperes.

(b) As a 0.80 Power Factor Motor—Referring to Fig. 2, the lines AC, AB, and BC represent the initial energy load, the total kilovolt-amperes and the wattless lagging kilovolt-amperes respectively, the same as in Fig. 1. A 1,000-kva. 0.80 leading power-factor motor is now to be added to the system. This motor will deliver a $1,000 \times 0.80 = 800$-kw. energy load, represented by the lines MF and CD. It will also deliver "wattless leading" kilovolt-

amperes equal to $BM = \sqrt{BF^2 - MF^2} = \sqrt{1{,}000^2 - 800^2} = 600$ wattless leading kilovolt-amperes. The 600 wattless leading kilovolt-amperes will neutralize an equal amount of the 1,600 wattless lagging kilovolt-amperes, so that the wattless lagging kilovolt-amperes after the motor is added will be $DF = BC - BM = 1{,}600 - 600 = 1{,}000$ kilovolt-amperes.

The energy load will then be $AD = AC + CD = 1{,}200 + 800 = 2{,}000$ kw., the wattless lagging kilovolt-amperes will be reduced to 1,000; and the total kilovolt-amperes required to carry this load will be $AF = \sqrt{AD^2 + DF^2} = \sqrt{2{,}000^2 + 1{,}000^2} = 2{,}235$ kva. The new power factor, after the motor is added, will then be $\frac{2{,}000}{2{,}235} = 0.895$ instead of 0.60. It will be noted also that the energy load has been increased 66⅔ per cent, with an increase of only 11¾ per cent in the generator capacity.

(c) As a 0.0 Power Factor Motor; That Is, a Synchronous Condenser—In this case the problem is: How much will the power factor of the system be increased by the addition of a 1,000 kva. synchronous condenser, it being the intention to keep the same energy load? Fig. 3, as in Figs. 1 and 2, again shows the initial energy load, total kilovolt-amperes and wattless lagging kilovolt-amperes by the lines *AC*, *AB* and *BC*, respectively. The 1,000-kva. synchronous condenser, neglecting the energy required to supply its losses, which may be only 3 or 4 per cent, will supply a wattless leading load 1,000 kva., equal to *BM*. The total wattless lagging kilovolt-amperes will then become $BC - BM = CM = 1{,}600 - 1{,}000 = 600$ kva., and the total kilovolt-amperes required to carry the same load will become $AM = \sqrt{AC^2 + CM^2} = \sqrt{1{,}200^2 + 600^2} = 1{,}341.6$ kva. The new power factor will then be $\frac{1{,}200}{1{,}341.6} = 0.895$. Not only is the power factor increased from 0.6 to 0.895, but it will be noted that, by the addition of this synchronous condenser, to carry the energy load a generator of only about two-thirds the former capacity is required, with a corresponding reduction in the capacity of all transforming and switching equipment, transmission lines and exciters.

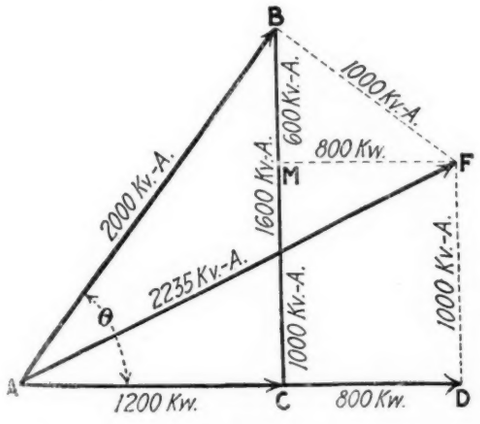


FIG. 2. DIAGRAM SHOWING EFFECT OF ADDING 1,000-KVA. 0.80 LEADING POWER-FACTOR LOAD TO A 2,000-KVA. LOAD

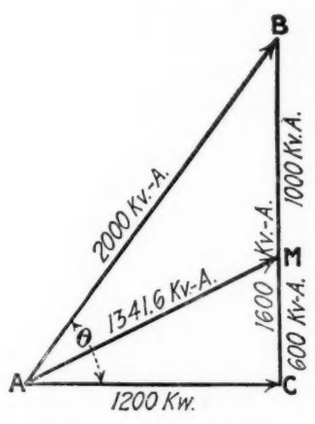


FIG. 3. ADDING 1,000-KVA. 0.0 LEADING POWER-FACTOR LOAD TO A 2,000-KVA. LOAD

The power factor is equal to the cosine of the phase angle between the volts and current. In the construction of Figs. 1, 2 and 3 angle θ is made equal to an angle whose cosine is equal the power factor. In the problem the power factor is 0.60 before correction is made; 0.60 corresponds to the cosine of an angle of approximately 53 deg., consequently angle θ in the figure is made 53 degrees.

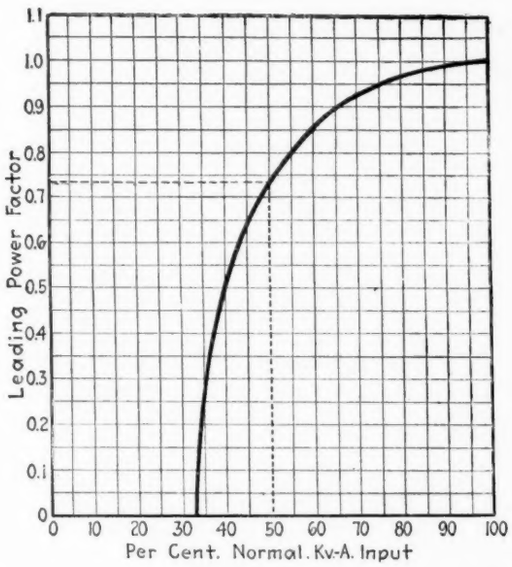


FIG. 4. POWER FACTOR OF SYNCHRONOUS MOTOR AT DIFFERENT LOADS, WITH FIELD HELD CONSTANT

In the application of synchronous motors the highest efficiency in the driving of mechanical loads can be obtained by the use of the unity power-factor motor. It requires less exciter capacity and costs considerably less than a synchronous motor designed to operate at leading power factors. Such a motor, of course, constitutes a non-inductive load on the lines; that is, it does not furnish any wattless leading kilovolt-amperes when operating at full load, but as shown in Fig. 1, it does improve the power factor of the system to a considerable extent. If, however, it is underloaded, with full-load excitation on the field, it always operates at a leading power factor furnishing a certain amount of wattless leading kilovolt-amperes to the line depending on the degree of underloading. Fig. 4 shows the leading power factor at which a normally designed, unity power-factor synchronous motor will operate at partial loads with the normal full-load excitation constantly maintained. It will be noted that at 50 per cent of the normal kilovolt-ampere output, the machine will operate at a 0.73 power-factor leading, and at about 35 per cent normal kilovolt-ampere input it will operate at 0.0 power factor; that is, purely as a synchronous condenser. In the average motor this value of kilovolt-ampere input at 0.0 per cent power factor will vary from 20 to 30 per cent.

The Framanco" Pump Regulator

A new type of pump regulator designed to maintain a constant differential between the discharge pressure and the steam pressure or a fixed pressure at the delivery end of the pump, has been perfected by the Framingham Manufacturing Co. for the Edward Valve and Manufacturing Co., of Chicago. The constant differential regulator will automatically maintain a fixed excess discharge pressure above the boiler pressure sufficient to overcome the friction head in the feed line and the static head. In services where it is desired to maintain a fixed pressure at the delivery end of the pump regardless of fluctuations in the steam pressure, provided, of course, there is sufficient pressure to operate the pump, a regulator of the constant-pressure type is employed. Regulators of either type are of the same construction, the only difference being in the application of the control cylinder and component parts.

One of the distinguishing features of the new regulator is the separation of the valve proper and the control cylinder, so that the operating mechanism is not subjected to the high temperature of the steam, thus eliminating expansion and contraction troubles. The working parts are in plain sight of the operator,

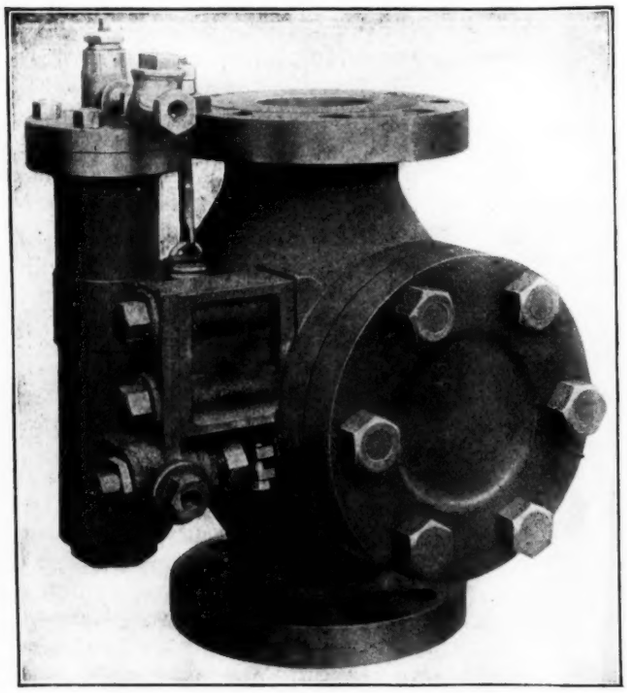


FIG. 1. FRAMANCO PUMP REGULATOR

and the proper size of control cylinder for the conditions existing in the plant can be attached to the valve proper.

The principle of furnishing a regulator to meet the particular operating conditions to which it is applied is further carried out in the application of the spring arm which connects the spring to the actuating shaft. This arrangement also serves to compensate for the extension of the spring, and its consequent increased tension by the shortening of its effective moment arm.

Fig. 1 shows the valve proper and the control mechanism in a vertical position. It will operate equally well in a horizontal line or in any other position. As shown more plainly in Fig. 2, the operating mechanism is bolted to the valve body, the latter containing the valve seats and a balanced disc made steam tight. The disc is actuated through a link and revolving shaft from the cylinder mounted on the side of the valve proper. For flexibility this cylinder contains a two-

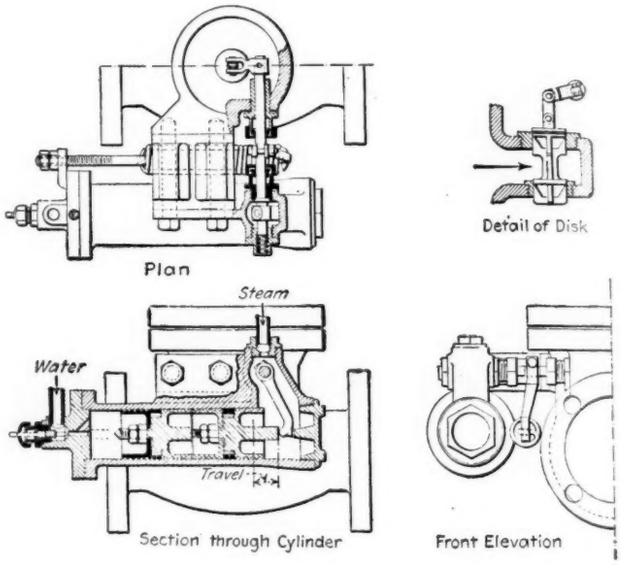


FIG. 2. DETAILS OF REGULATOR DESIGN

part piston with steam pressure on one side and water pressure on the other, the differential being secured by tension on a spring located between the valve proper and the control cylinder. By means of a screw adjustment the spring tension may be varied so as to vary the differential as desired.

When the regulator is used to control the pressure of feed water to the boilers, the valve proper is installed in the steam lead to the boiler feed pump and one end of the control cylinder is connected to the same line. Water pressure is admitted to the other end of the cylinder through a connection from the discharge line of the pump.

With the steam pressure and the spring operating on one end of the piston and the water pressure on the other, after proper adjustment has been secured, the whole mechanism is in equilibrium. Anything that disturbs the balance causes the piston to move in one direction or the other, closing or opening the valve, as the case may be. Referring to the sectional view, Fig. 2, should the steam pressure increase or the water pressure for some reason be reduced, the piston moves to the left, the spring causes the operating arm to follow the piston, thus rotating the shaft and opening the steam valve. More steam causes the pump to speed up, which in turn increases the water pressure until the balance is restored. It is claimed that with a normal pressure of 175 lb. an increase of less than 5 lb. will close the valve and stop the pump, or a decrease of two to three pounds will cause the valve to open full, admitting the full steam-line capacity to the pump. The steam connection to the control cylinder is always made from above so that condensation will collect in the steam space and insure a practically uniform temperature at both ends of the cylinder.

EDITORIALS

Proposed Super-Power Station

THE LEADING article in this issue deals with a proposed super-power station. It is proposed to design this station with multiples of thirty-thousand kilowatt turbines and a total station capacity as high as five hundred thousand kilowatts is suggested. A supplement illustrates the general idea and shows many innovations, which, although most of them may be found in part in a number of stations, have not all been incorporated in any one station.

This design of super-power station has for its basis a grouping of boilers and turbines as a single unit, four boilers supplying steam for one turbo-generator. Two thirty-thousand kilowatt turbines and eight seventeen hundred and sixteen horsepower boilers are to comprise a unit.

Without doubt the present tendency is toward larger power stations. The practice, however, has been, in the main, to pipe all boilers to a common steam header from which branch pipes are led to the various turbines. In some instances the group plan has been adopted; that is, certain boilers have been laid out to serve a certain turbine or turbines. In such instances the boilers have generally been housed in a single boiler room and the turbines in a turbine room, with a brick wall between the rooms.

Mr. Stevens goes a step farther in carrying out the group plan, and while proposing that four boilers shall supply steam to one turbo-generator set, he does not interconnect one group of four boilers with a second group of the same number. Moreover, but four boilers are permitted in one boiler room and but eight boilers are housed in the same structure. If the station capacity is, say, one hundred and twenty thousand kilowatts, two separate buildings are to be used having an explosion gap between them of at least twenty feet.

The idea of an explosion gap is also carried out in regard to the boiler room being separated from the turbine room, where in the proposed station a low pump-room separates them and a brick wall separates the turbine room from the switchhouse. Even the turbine room is protected by an explosion wall between two turbine units.

In this construction there are several obvious advantages, the main one being that in case of a boiler explosion, which is remote under present practice, the damage would be confined to one boiler room, or at the worst to one boiler house. The same would apply in the case of a tube rupture or the bursting of a steam main or branch pipe.

Thirty thousand kilowatt turbines are specified because this size is within the zone of maximum economy in practice, and it is about the limit of size that can be supplied with four units of boilers, which in this proposed station are served by one stack.

At the top of the station it is planned to have an operating room containing every known device for boiler-plant operation, thus enabling the master boiler operator to make hourly tests of boiler output, if so desired. Even periscopes are provided for observation of the furnaces and for reading the water level in the gage glasses.

Sleeping quarters and baths are provided. A riot alarm whistle, searchlight and wireless equipment are adjuncts to the general apparatus. Telephones are to be located wherever required in order to obviate the necessity of the men wasting time in getting into communication with the chief operator.

Warm air is to be taken from the generator, but a stop valve will prevent dust and soot from being blown back into the turbine in case of a tube rupture in the boiler. Coal and ashes are to be handled by means of full-sized railroad cars, and the track design is such that the largest type of locomotives can run through the plant. An examination of the supplement shows many devices and arrangements of apparatus that have not been mentioned herein.

No claim is made by the designing engineer for originality in the application of the ideas to this super-station, and criticism will be welcomed.

Conservation the Only Way Left To Meet the Fuel Situation

THE best of America's soft coal is going to Europe in quantities which we are not in a position to say; but it is conservative to state that they are large. In fact, the neck of the bottle now is not ships to carry coal, but port facilities at Hampton Roads to clear the volume demanded. Europe surely cannot furnish its own coal in adequate quantities for a long time to come, probably not within the next three years. And as long as Europe is in this shape, depend upon it, she will gladly pay for the high heat value American coals, and coal prices as well as coal availability will continue to be a problem to American industries.

The fact that most people do not have to the fore in their minds is that fuel is a basic commodity; it is the very foundation of modern civilization.

Oil fuel presents a more serious outlook than coal. It is certain that, generally, we cannot look to it to materially alleviate the coal situation. There is not enough of it coming out of the ground. We are beginning to realize that oil is essentially a marine fuel. And before many years we may be reconciled to the belief that it is a naval fuel. For surely, long, long before there are indications that the supply is meager, the navies of the world will cause fuel oil to be unavailable for purposes other than their own. And the marine demand today, naval and merchant, is what is causing the scarcity and high price of oil to land consumers.

It should interest industrial fuel consumers to know that the engineers of the United States Shipping Board Emergency Fleet Corporation more than a year ago completed boiler and stoker designs for ships. They did so not only for some of the ships which were soon to use coal, but to prepare for the day when there might

be a greater number burning coal than oil. Even the most efficient arrangement of baffles for these stoker-fired marine boilers has been determined.

Engineers must see that the only hope of meeting the fuel situation is by economy in its use. The need for conservation is every bit as great now as at any time during the war.

The situation is abnormal; that is, fuel economy is today somewhat a different problem than it is ordinarily. Time was when the purchaser of coal could not only choose the grade he would have, but could buy it according to specification. Today he is glad to get anything that can be charitably called coal. And most consumers cannot get enough of that kind. One can do much to get low fuel consumption if one begins with the design in a new plant. But few new plants are being built. Money is in such condition that such a thing as remodeling the boiler room, or whole power plant is, in most places, out of the question. One cannot buy new equipment when the chief determining factor in its selection is coal, which cannot be chosen. But there are many appliances which will be worth-while if purchased, provided these are not already a part of the plant.

There never was a time when engineers should more diligently keep records of the plant's performance and more minutely follow up what the records show. The plant today which is not at least weighing its coal and water deserves censure. The management which permits its plant to run without providing it with equipment to check performance is not on its job.

Unity Power-Factor Synchronous Motor

OF THE three applications—as a unity-power-factor motor, a synchronous condenser or a combination of both—the unity-power-factor synchronous machine is the most efficient. The exciter capacity required is less, and the cost is lower than that of a machine designed to operate at leading power factor. Such a machine at full load will constitute a unity-power-factor load on the system and will therefore help to improve the power factor of the system as a whole. At less than full load, with full-load excitation on the fields, the machine will operate at a leading power factor and will supply a certain amount of leading kilovolt-amperes that will compensate for an equal amount of lagging kilovolt-amperes required by induction motors on other inductive equipment.

Elsewhere in this issue is an article on the "Unity-Power-Factor Synchronous Motor," by W. T. Berkshire. One of the features of this article that is of particular interest is the curve showing how the power factor of a synchronous motor with constant field excitation becomes leading as the load decreases. This characteristic is the reverse of the induction motor, in which even at full load its power factor is never above eighty-seven per cent lagging and drops to low lagging values if the load is materially reduced. In a comparison of the power-factor curve referred to in the foregoing with that of the average induction motor, it is found that at fifty per cent load the power factor of the synchronous motor is about seventy-three per cent leading, where that of an induction motor is around sixty-five or seventy per cent lagging. This means that if the load is reduced on a synchronous motor, it acts to improve the lagging power factor of the system, whereas, if the load is reduced on an induction motor it acts to make the lagging-power-factor conditions worse. In other words, if an induction motor is operating underloaded, not only is its efficiency reduced, but it has a deleterious effect upon the power system as a whole. When a synchronous motor is operating at reduced loads, its efficiency will also be reduced, but it will develop characteristics that improve the operation of the system, therefore compensating in a measure for the loss in efficiency.

Constructive Legislation

THE appropriation of one hundred and twenty-five thousand dollars recently recommended in the Sundry Civil Bill, to be expended in determining what the power requirements are for the industries and railroads in the North Atlantic Seaboard States and how to most efficiently meet these needs is a step in the right direction and is worthy of the support of every American citizen. This appropriation carries with it the privilege to use private funds. At this time there is no better opportunity for public-spirited men to do this country a great service than to see to it that the necessary funds are forthcoming to make this investigation with.

The American Institute of Electrical Engineers, through President Calvert Townley, has appointed a committee on the super-power system, consisting of W. S. Murray, chairman; H. W. Buck, H. V. Bozell, George Gibbs, J. W. Lieb, Malcolm MacLaren, William McClellan, C. S. Ruffner, E. B. Rushmore, C. F. Scott and Percy Thomas. With the Government appropriation forthcoming to carry on the work, it is most gratifying that the investigation will receive the support of these eminent engineers and one of our National engineering societies.

Experts estimate that we burn up each year in this country two and one-half billion dollars' worth of by-products in the five hundred million tons of bituminous coal used; that three hundred million dollars each year is wasted by our present methods of power generation in the industrial region extending from north of Boston to Washington, D. C., and from one hundred to one hundred and fifty miles inland from the coast. It is estimated that we have over twenty million continuous horsepower of undeveloped water powers. If this were all developed and available, it would result in a saving of three hundred and fifty million tons of coal per year, allowing an average of four pounds of coal per horsepower-hour. In artificial illumination we are wasting two hundred million dollars' worth of light each year according to the experts. These are only some of our power wastes; there are many others. Are we going to continue to tolerate them?

In certain type of substations material reductions in first cost have been obtained by installing the equipment out of doors. Although in some small isolated installations, where climatic conditions are extremely favorable, boilers, engines and generators have been installed in the open, no definite effort has been made to apply this practice generally. With the cost of power-plant installations rising to undreamed of heights, has the time not arrived to investigate the possibilities of outdoor power plants to determine if a large percentage of the investment required to house the equipment by our present practice cannot be eliminated?

CORRESPONDENCE

Pulverized Coal Under Boilers

The writer read with considerable interest the remarks published in *Power* under date of April 27, 1920, on page 681, by T. A. Marsh, chief engineer of the Green Engineering Co. In the first paragraph Mr. Marsh states that he believes it fundamentally wrong to take coal and burn it in a powdered condition. I believe that it is better and easier to burn coal in pulverized form than it is in lumps on grates subjected to the action of the heat.

In the second paragraph Mr. Marsh claims that some accurate way of measuring the ash discharge from the stacks from pulverized-coal-fired furnaces should be found before definite statements concerning it are made. It is true that a large percentage of the ash from pulverized-coal-fired furnaces will be discharged from the stack. The percentage, however, dissipated from a first-class installation equipped with economizers and settling chambers will not be sufficient to cause a complaint, as has already been shown by installations using pulverized coal in thickly populated districts. This question of ash dissipation depends greatly upon the velocity of the gases passing through the setting, and the percentage would naturally vary according to the operating conditions and the general design of the installation, the same as that ash discharged from a stoker installation would vary according to the conditions under which the stoker is operated.

In his fourth paragraph Mr. Marsh states that the cement industry has more data on the subject of pulverized coal than have steam producers. This statement is correct, and we do not hesitate to assert that we have more data on what is being done in connection with pulverized coal in the cement industry than any other organization, and we are thoroughly familiar with every installation in the cement industry in the United States and Canada. We are positive that any plant in which the cost is as high as one dollar per ton to prepare the coal is not being efficiently operated, unless the particular coal plant has a very small capacity and unless the plant is operated only periodically.

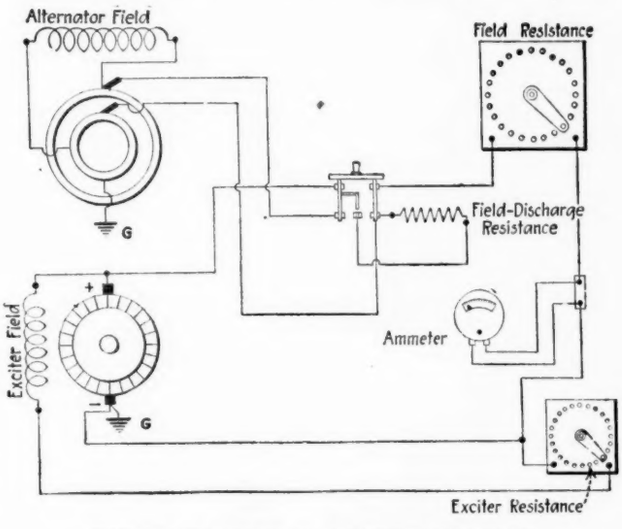
In order to show just what the cost of preparing coal is at the present time, we would like to say that during the month of August, 1919, at the plant of the Allentown Portland Cement Co., 2,976 gross tons of coal were pulverized and the actual cost of pulverizing was as follows: Drying, 0.0804; grinding, 0.0874; operation, 0.0043; power, 0.1793; labor, 0.0368; repairs, 0.0765. Total, 46.44c. per gross ton, or 41c. per net ton, no interest or depreciation included. This can be taken as representing the average cost in portland-cement plants in the Lehigh Valley district, for the quantity of coal pulverized daily from which these figures are taken is low, and no doubt in larger plants they would be modified materially.

The cost of preparing coal will vary primarily according to the quantity pulverized daily, so that any general statements or criticisms that are made as to the cost in one plant have no bearing on the subject as a whole.

H. G. BARNHURST, Chief Engineer.
Allentown, Pa. Fuller Engineering Company.

Grounds Cause Alternator to Lose Field Control

A suitable resistance was installed in the field circuit of a 120-kva. three-phase 60-cycle 600-volt alternator, with direct connected exciter, to operate in parallel with other units. When testing the unit I found the regulation satisfactory until about half the resistance was cut out, when the voltage jumped to its full value and the field ammeter failed to give a reading. The resistance box was tested and found to be in good condition, then all wiring was checked. The trouble was finally located in one brush-holder on the exciter and one collector ring on the alternator being grounded as in the diagram. After these repairs were made, the control was satisfactory again.



WIRING DIAGRAM OF EXCITER CIRCUITS

P. A. TOPPER.
Philadelphia, Pa.

Central-Station Operating Code

In the editorial in the Mar. 9 issue, "An Operating Code for Large Central Stations," a sentence reads, "This means that without large turbines there is an absence of large condensers, boilers and other allied apparatus."

In the industrial power-plant field it is not uncommon to see boiler plants that are fully as up-to-date and that contain as large units as are found in some of the large central stations.

Some years ago a turbine or reciprocating central station with twenty or thirty boilers was unusual; industrial plants, however, equaled that many and even more. Since then the central station has advanced wonderfully and so have industrial power plants.

Operators in large industrial plants, even though the mechanical output may be of only a few thousand horsepower, are obliged to furnish a large volume of steam, and this performance requires just as efficient units as the central station.

I believe that the central station should take care of its own code, to be adopted universally if possible, but each station of which I have knowledge has methods differing quite materially from the others.

New York City. C. W. PETERS.

Fatal Accidents Occurring on Low-Voltage Circuits

Your editorial on page 341 of the March 2 issue, "Fatal Accidents on Low-Voltage Circuits," refers to the report of G. S. Ram, electrical inspector of factories in England, in which he shows that of ninety-nine fatal electrical accidents occurring in England during the period from 1915 to 1918 inclusive, seventy-nine were on circuits of five hundred and fifty volts or less, while only twenty were on circuits of one thousand volts and over. From this data you draw the conclusion that low voltages are as dangerous as high voltages, and I beg to take issue with you, not on your conclusion, but on your method of drawing it. Certainly, voltages of one thousand and over are in much less general use than the lower voltages, and consequently there would be much greater opportunity for accidents occurring around the number of low-voltage machines in use than around the much smaller number of high-voltage (above one thousand) machines in use.

However, I think that your conclusion is well taken, and a personal experience may be of some interest in this connection. I was using a Parr adiabatic combustion calorimeter, which was connected up to a 110-volt circuit for the purpose of firing the charge of coal in the small capsule, by means of a fuse wire. In connection with the calorimeter there was also a small water-circulating system, which furnished hot water. I was accustomed to putting my hand on a piece of one-inch pipe that formed one side of the water system, to determine whether the water was hot enough. Thinking that the current was off (but it happened to be on and connected to the metal top plate of the instrument), with my left hand on the top plate, I reached down and took hold of the water pipe to find out how hot the water was. The shock almost caused me to jerk the heavy calorimeter onto the floor, trying to pull loose. This incident greatly increased my respect for a 110-volt circuit, which I had always been given to understand was not at all dangerous.

The inspector and meter tester of the local public-service company later told me of some of his experiences with several near fatal accidents in which workmen had handled low-voltage circuits. The cause seemed in each case to have been carelessness in the matter of grounding. In one case it was found that the victim of the shock had been sent to a creamery to do some repair work and had been making the change while standing in a pool of water. Incidents like this would seem to indicate that workmen are, as a rule, very careful about the ground connections when they are working with higher voltages, even with the voltages used on street-railway systems; while at lower voltages they become more careless because they think there is comparatively little danger. Some reliable data on this, and public education, would, I think, be very desirable.

Decatur, Ill. W. J. RISLEY, JR.

Increasing Boiler Output by the Help of a CO_2 Recorder

In an editorial in the April 20 issue of *Power*, entitled "Increasing Boiler Output," you suggest either the installation of forced-draft mechanical stokers or, when hand-fired furnaces are retained, equipping them with some device for increasing the draft. Another method, not mentioned in your editorial, is the installation of CO_2 recording equipment. The CO_2 recorder is generally thought of as a means of saving fuel rather than for increasing capacity, but it may be applied primarily for either purpose.

As an example, assume a boiler plant consuming ten tons of coal per day. Suppose it is found by the use of a CO_2 recorder that the excess air can be reduced to such an extent that the same capacity can be maintained by burning nine tons per day. This, of course, results in a saving of coal cost and is highly desirable. Suppose, now, that increased capacity is desired and that the original amount, or ten tons of coal per day, is burned, but that with the aid of the CO_2 machine the improved efficiency is maintained, with the result that the capacity will be increased by approximately 11 per cent.

The matter of draft is another important item to be considered. Many plants are today struggling to take advantage of all the draft possible in order to increase capacity, but are supplying so much excess air that they are not able to realize the available capacity. The engineer may complain that the chimney is not big enough and it may not be big enough, to handle the quantity of gases discharged into it; but as soon as the quantity of excess air is diminished to economical proportions, the volume of hot gases shrinks, and the chimney, relieved of its overload, has no difficulty in handling all that is required of it.

In a certain case a battery of four boilers equipped with stokers was unable to meet the demand for steam, and the purchase of two additional units was contemplated. CO_2 recorders were first installed, however, and by reducing the excess air, so much additional heat was absorbed by the boilers that one unit could be cut out of service and the three remaining boilers had ample capacity to meet all the required demands. The use of a CO_2 recorder will, obviously, often result in a very inexpensive increase in boiler-plant capacity and at the same time reduce the fuel cost per boiler horsepower.

New York City. F. F. UEHLING.

Symbol for B.T.U.

For some fifteen years I have used the symbol shown herewith as a substitute for the three letters B.t.u. They are combined in the symbol and are speedily produced with two strokes of the pencil without the use of periods. Having found it convenient, I submit it with the hope that others interested may find it equally helpful.

Kansas City, Mo. R. L. WEBER.

The Designer of This Heating System Meant Well

It has occurred to me that perhaps the readers of *Power* might like to know how a first-class engineer carried out a job some years ago. He was the only man in a group of three or four towns who had a first-class license, and he boasted that the inspector who visited his plant had complimented him highly on the control for the steam-heating system, which was his own idea and one that he had never even heard of or seen anywhere else.

This factory was three stories high with basement and attic, and heating coils of the trombone pattern were installed. In one corner of the engine room was a

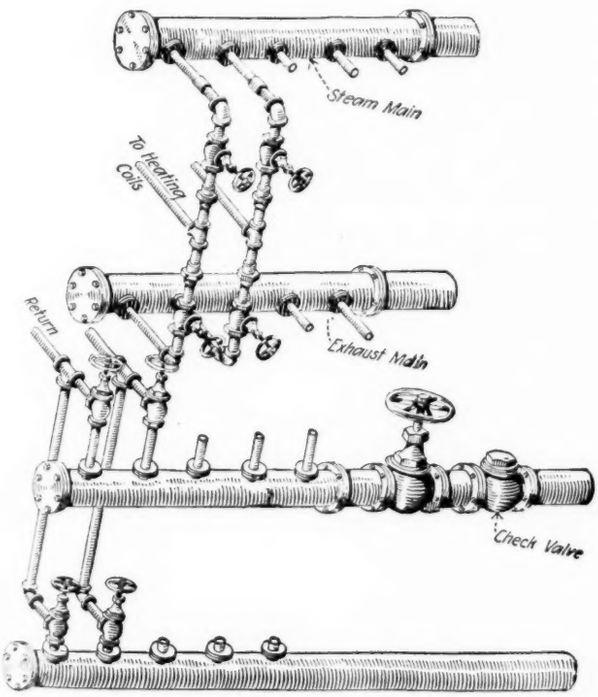


FIG. 1. ARRANGEMENT OF CONTROL IN BOILER ROOM

layout as shown in Fig. 1. A live-steam manifold made up of tees and nipples was suspended in a horizontal position about eight feet from the floor. Under this, perhaps thirty inches, was another line, but of larger fittings for exhaust steam. A series of vertical pipes connected the two manifolds.

Midway between the manifolds on each vertical line was a tee, and a valve was placed on the live-steam side and one on the exhaust-steam side to control either live or exhaust steam to the tee, the outlet of which was piped to the heating coils. Each pipe line ran to a separate heating coil. It will be seen that either exhaust or live steam could be used at will on the heating coils.

All returns were brought back through individual pipes, and the control was so arranged that the return could (if exhaust) be turned into the same, or if live steam were used it could be returned to the boilers.

The designer of this layout went to another position before the system was completed, but he left drawings

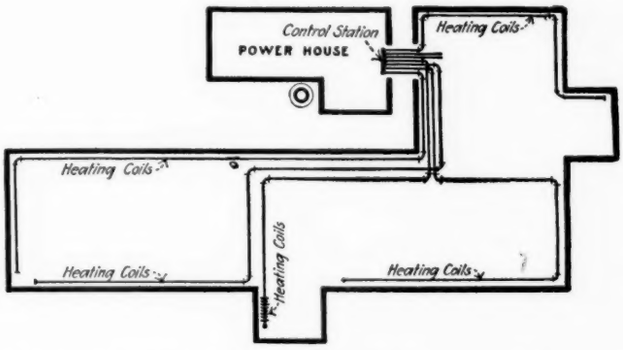


FIG. 2. PRESENT ARRANGEMENT OF HEATING SYSTEM

and recommendations for his successor to follow. I happened to be the victim, and here is what I found: The coils throughout the factory were of the trombone type, and before steam got halfway through the shortest coil, it had turned to water, and yet the system was designed to return the water to the boilers by gravity. Exhaust steam was likewise introduced to the coils through the same 1¼-in. pipe, and about fifteen pounds back pressure was necessary to get the exhaust even into the first pipe of the coil.

As the southern exposure was a good place to use exhaust steam, I rebuilt four coils, making them into the manifold pattern and feeding them with a 4-in. line. On the ends of the coils was coupled an old single-plunger pump, belted to the lineshafting and operated only when the engine was running, but as there was no exhaust steam except when the engine was running, it worked all right.

I could turn live steam through this line to get it warmed before starting, and a bleeder near the pump took care of the return.

By the end of the first winter I introduced a home-made condenser near the plunger pump, and one pound back pressure on the engine took care of the heater and the coils in the south side of the building.

By running a 4-in. live-steam pipe directly to the north side of the factory near the stair tower and putting up a riser, I was able to return the water by gravity from six coils to the boiler. Fig. 2 is a plan of the present system.

The moral seems to be that trombone coils are not practical for gravity return systems and that control from one point is not always an advantage; also that ample area must be allowed in the piping so that the drop in pressure will not be excessive; and finally, that the power-plant man with experience in handling units of thousands of horsepower makes a very poor designer for the small plant, unless he has started his career in the small plant and knows its needs.

New York City. C. W. PETERS.

Favors the Oil Engine

We have 500 hp. in steam engines, 150 hp. in gas engines, and 190 hp. in electric motors, the last operating on central-station current. We burn coal costing $3.50 per short ton for steam making and city gas of 650 B.t.u. per cu.ft. at 70c. per 1,000 cu.ft. in the gas engines; central-station current at 2.02c. per kw.-hr. is supplied to the motors. For the oil-engine estimate we will assume oil as costing 5c. per gal. and 6 gal. per horsepower-hour. Based on these costs, 940 hp. of electric current for one month of 25 ten-hour days would cost $3,562; steam and gas per month would cost, fuel and labor, $2,491, and oil and labor for oil-engine power, $1,237. Reduced to kilowatt-hours this gives for central-station current a cost of 2.02c. per kw.-hr.; steam and gas power, 1.41c. per kw.-hr., and for the oil engine, 0.7c. per kilowatt-hour.

It looks as if the oil engine had the best of it in operating costs, and with twenty years' experience in making gas engines do their work with reliability and economy, I have no fear of not getting satisfactory results from an oil engine.

In the past, with cheap fuels, we have been unable to see much of anything except first cost, but that day has gone. Economy of operation must play a more prominent part in the selection of power apparatus.

A good steam, oil or gas engine directly coupled, driving a lineshaft, has the advantage that several losses are avoided with which the central station has to contend. I have always contended that with first-class equipment and attendance the average mill or factory power plant can make its own power at a profit over purchased power. Frequently, however, where the cost of power is but a small part of the total costs of manufacturing, this is given but little consideration.

Anderson, Ind. J. O. BENEFIEL.

Suggested Changes for Diesel Engines

In order to bring about more satisfactory operation of the Diesel type of engine, one of the first things the designer should do is to remove the high-pressure air compressor from the engine. The present direct-connected air compressor, in the writer's opinion, causes many shutdowns, and the accompanying dissatisfaction.

It is difficult to understand why the compressor was ever directly connected to the engine, as it is not an efficient drive. I would suggest the adoption of a small three-stage high-speed vertical compressor driven by an electric motor, small engine or from a shaft. A motor-driven compressor, with inclosed silent-chain drive running in oil, would make an ideal unit. There should be at least two such compressors in each plant. If the plant contains more than one engine, the compressors should be so arranged that one would supply air for all the engines and the other held as a reserve. Then, if one broke down, the other could be cut in without shutting down the engines.

The air compressor on a Diesel engine is like unto the boiler-feed pump in a steam plant, and it is not much of a steam plant that has but one feed pump. The same will be said of the air compressor in the Diesel plant. The independent compressor could be made an efficient unit, because its speed could be regulated according to the air requirement.

The oil pump on a Diesel engine is comparable to the boiler of a steam plant, but in all large power plants there is at least one reserve boiler. Two oil pumps should be placed on each engine, one to be held in reserve. They should be independently operated or they could be operated from the camshaft, but so fitted that either pump could be repaired while the other pumped the oil, and this without shutting down the engine. I lay 15 per cent of the engine shutdowns to the oil pump.

Another fixture that would be of advantage on the Diesel engine is a duplicate fuel-oil injector valve. Two of these valves could easily be put on, and, then, when one went wrong the other could be cut in. It would, however, be some job to design these valves so that one could be repaired while the engine was being operated, but it can be done. At least a spare valve or two, complete with cages, should be kept on hand and in repair, to be put in when the engine was shut down for some other cause.

In my opinion, 75 per cent of the shutdowns could be eliminated if oil engines were built with duplicates, as outlined in the foregoing. The remaining 25 per cent of the shutdowns are due to the load, the engine itself and other little causes, but not more than 10 per cent are caused by the engine itself, if it is properly operated and closely watched.

A crosshead on large engines should be used, but not one that will permit the crosshead to lift from its guides. The crossheads now in use keep the greatest wear from the cylinder and piston and are far better than no crosshead at all. The pistons have a job all their own and should not be called upon to do the work of a crosshead as well. It costs money to put in a crosshead, but why not spend a little more on the first outlay and cut out repair and high depreciation costs? A crosshead permits of the necessary adjustment to take up the wear.

The piston should be fitted with at least three oil grooves, properly spaced and extending all the way around it, if a vertical piston. If it is a horizontal piston, the grooves should extend all the way around except for about one-half inch at four points and staggered so as to make the groove hold the oil and prevent it from flowing to the bottom of the cylinder. It is also well to have an oil groove in the cylinder of large engines. But all grooves should be cut large to prevent them from becoming clogged.

A light oil-feed pump should be provided to furnish lubricating oil to the cylinder, and it is a good plan to have the connections enter the cylinder at three points. A low-oil alarm should be placed on the oil pump as a precaution. It takes but a few minutes for trouble to develop with such high temperature and no oil and very serious trouble it may become in the course of time.

Some types of internal-combustion engines operate with a water-injection system. It can, to a certain extent, be applied to all such engines, and would help, I think, and also do away with considerable noise and would accomplish about all the water-injection method is supposed to do.

I would run the cooling water from the jackets down over the baffles in the air-intake box. The intake air passing through this spray of warm water would become saturated with moisture and would be so under all conditions and at all times. This air would also be free of dust and grit and would be in the proper condition to enter the cylinders. GEORGE J. TROSPER.

Winkelman, Ore.

INQUIRIES OF GENERAL INTEREST

Kerosene in Boilers—What are the objections to the use of kerosene for the prevention or removal of scale from boilers? W. G.

Kerosene, especially when used in excessive quantities, is likely to cause leaks in the boiler and to distill over and attack gaskets and pipe joints. When introduced into boilers in which there is already a deposit of scale, the loosening and accumulation of the scale in the bottom of the boiler may cause blistering and bagging of the boiler metal.

Pressure in Closed Heater Higher Than Boiler Pressure—Why is it necessary to have a higher relief pressure for the safety valve on a closed feed-water heater than the blowoff pressure of the boiler safety valve? W. H. B.

For boiler feeding, the pressure in the heater must be as much higher than boiler pressure as may be necessary to overcome the losses of pressure sustained in discharging the feed water from the heater through the piping and fittings in the feed line, and boiler-check valve, to the boiler.

Lift of Jet Pump—Water is raised by a steam jet pump to a height of 4 ft. 6 in. above the pump, and the suction water is supplied at a pressure of 1 lb. per sq.in. What is the lift of the pump? M. M. W.

If the suction water is delivered to the pump under a pressure of 1 lb. per sq.in. = 2.3 ft. head, and the pump is capable of discharging to a level that is 4 ft. 6 in. above the point where the suction pressure is measured, then the net lift of the pump is 4.5 − 2.3 = 2.2 ft., or about 26½ in.

Choking Pressure Gage Cock to Dampen Vibrations—Will dampening the vibrations of a pressure gage by choking the gage cock give true indication of the average pressure? C. T.

The pressure indicated will be only an approximation of the average. When there is leakage around the joint of the plug of the gage cock, especially when the cock is nearly closed, the true pressure will be greater than the pressure indicated by the gage, and on that account readings should not be relied upon unless the connections are tight.

Necessity of Unequal Laps for Equalizing Cutoff—For equalizing cutoff with a D slide valve, why is it necessary to set the valve with more lap on the head end than on the crank end? G. N. H.

On account of angularity of the connecting rod a fewer number of degrees of rotation of the eccentric is accomplished for a fraction of stroke from the head end than from the crank end. Hence, to obtain closure of the valve for cutoff to take place as early in the stroke from the crank end as from the head end, the valve must have more lap on the head end.

Water Power Available for Electric Generator—What number of horsepower can be realized for an electric generator from a turbine waterwheel supplied by a stream flow of 10 cu.ft. of water per second, where there is a total fall of 17 ft? R. R.

The net working head realized will depend on the loss of head sustained in getting the water to and from the turbine, depending on the character of the development, and for a given net head and given rate of flow the power realized depends on the efficiency of the turbine and transmissive machinery. Assuming that the available net working head is 14 ft. and the combined efficiency of the turbine waterwheel and transmissive machinery is 70 per cent, the power realized would be

$$\frac{14 \times 10 \times 62.3 \times 60}{33{,}000} \times 70 \text{ per cent} = 11.1 \text{ hp.}$$

Power Factor of an Unbalanced Load—In our plant we have a three-phase, 2,300-volt, 250-kw. alternator. How can I find the power factor from the readings of the polyphase wattmeter, ammeters and voltmeter? The ammeters do not all read alike. R. A. W.

Power factor is the ratio of the watts to the volt-amperes. The wattmeter reads directly in watts. If the load is balanced on a three-phase circuit, the volt-amperes equal the voltmeter reading times one ammeter reading multiplied by 1.732. Where the load is not balanced, the volt-amperes equal the sum of the three products obtained by multiplying each ammeter reading by the volts measured to the neutral point. For example, on a 2,300-volt circuit the wattmeter reads 95 kw. and the ammeters read 25, 30 and 35 amperes, respectively. Since this is a three-phase circuit, the volts to neutral equal 2,300 ÷ 1.732 = 1,328. The products of volts to neutral and ammeter readings are 1,328 × 25 = 33,200, 1,328 × 30 = 39,840 and 1,328 × 35 = 46,480, respectively, and the total volt-amperes = 33,200 + 39,840 + 46,480 = 119,520 watts. Then the power factor = watts ÷ volt-amperes = 95,000 ÷ 119,520 = 0.79.

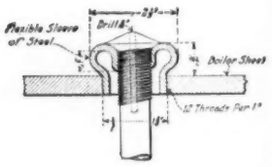
Motor Field Coils Burn Out.—What causes the field coils of a four-pole shunt motor to burn out frequently? The motor will operate satisfactorily for a week or ten days, and then one, and sometimes two, of the field coils will be roasted out. The field coils are not grounded when they fail. J. C. L.

If the same coils burn out each time, the trouble, no doubt, is due to the coils that do not burn out being short-circuited or grounded, consequently putting full-line potential across the coils that burn out. It would be advisable to see to it that the coils that do not burn out are not short-circuted or grounded, as it is almost certain that this is the source of the trouble. If one of the field coils of a direct-current motor is short-circuited or grounded, it will not cause this coil to burn out, but would put a higher voltage across the other coils in the machine, which might cause the latter to be destroyed. If there is any electrical disturbance causing this trouble, it is probably due to the controller used on the motor. It is not stated what type of controller is being used or what the motor is used for. The trouble complained of frequently occurs on elevator or other types of automatic controllers where conditions exist that open the field circuit, and cause a heavy voltage to be induced in the coils, which either breaks down the insulation of the field coils or of the armature. It may be that some such condition as this exists in the motor's controller. If so, the controller should be adjusted so as to prevent opening the field circuit.

Condensed-Clipping Index of Equipment

Clip, paste on 3 x 5-in. cards and file as desired

Staybolt, Gallagher Flexible
P. F. Gallagher, Clifton, S. I.
"Power," March 16, 1920

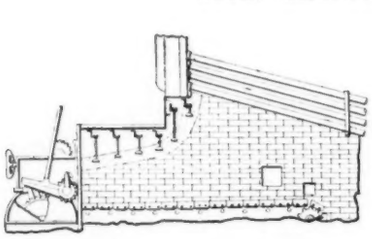


This staybolt consists of a flexible steel sleeve 2¼ in. at its largest outside diameter. The sleeve is threaded to screw into a 1¾-in. tapped hole in the boiler sheet, and is also threaded to take a drilled 1-in. diameter staybolt at the threaded portion. The flexible sleeve extends ½ in. beyond the boiler sheet, and is 3/16 in. thick. The staybolt is 1 in. in diameter at the threaded portion. This design permits of a staybolt 1 in. longer than could be used if the staybolt were screwed directly into the boiler sheet. The idea of the design is to obtain flexibility in the steel sleeve instead of having the strain come upon the threaded joint where the staybolt screws into the boiler sheet.

Chain, Sure-Lock Link-Belt Chain
Vulcan Link Belt Co., Inc., Endicott, N. Y.
"Power"

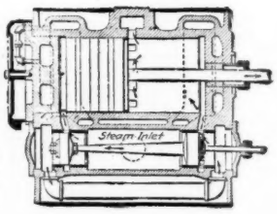
The links of this chain lock over at right angles. The lugs on the inner side bar rides the flanges of the hooks. The links will not detach except when at right angles, which position does not occur even in abnormal operation. The belt operates with the sprocket teeth against the back of the hook, but may be driven in both directions. There is practically no wear or friction on the inner face of the lugs, their purpose being to prevent the links from becoming detached.

Arch, Shaw Suspended Boiler
L. S. Shaw & Co., Union Building, Cleveland, Ohio.
"Power," March 23, 1920



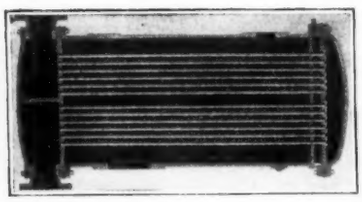
This arch is constructed by suspending forms from crossbeams and filling in between with a compound consisting of firebrick material of silica and alumina fireclay that is highly charged with asbestos fiber, and is free from expansion and contraction. The monolith arch is adaptable to all furnace design and irregularities in construction, and it is only necessary to pour into a form similar to that for pouring cement. After the firebrick has been baked, it presents a firebrick surface that is exposed to the fire all suspension bolts and girders being protected from the heat of the furnace. It is simple to build, easy to repair, and but few repair parts are required to be kept on hand.

Engine, Harrisburg Dual Clearance
Harrisburg Foundry and Machine Works, Harrisburg, Pa.
"Power," March 30, 1920



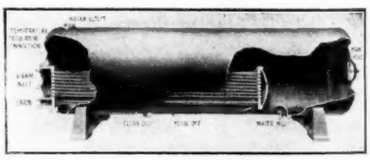
The latest development in engines of the uniflow type incorporates a design having two clearances. Steam is expanded from a small clearance and, by means of a single-balance piston valve, is allowed to compress first into a large chamber and finally, as the piston nears the end of the stroke, into a smaller clearance. The steam that has been compressed into the large chamber enters, due to the automatic action of a valve, into the cylinder at the opposite end and, mixing with the expanding steam on the return stroke, expands with it and passes out through the central ports to the exhaust line.

Condenser, New Wheeler Auxiliary Tube-Plate
Wheeler Condenser and Engineering Co., Carteret, N. J.
"Power," Feb. 10, 1920



The condenser is used chiefly in connection with salt circulating water. The tubes are expanded into a tube plate, which eliminates the possibility of leakage at that end. At the other end the tubes are provided with standard ferrules and condenser packing. The packing permits the tubes to expand freely and yet maintain an almost leakless joint. At this end of the condenser a thin auxiliary tube-plate or baffle is provided through which all the tubes pass. The holes in this plate are of such size as to make a sliding fit with the tube. In case of leakage, the circulating water drops to the bottom of the compartment between the two tube-plates and is then carried off through a drain at the bottom.

Heater, Russell Storage
Griscom-Russell Co., 90 West St., New York City.
"Power," March 16, 1920

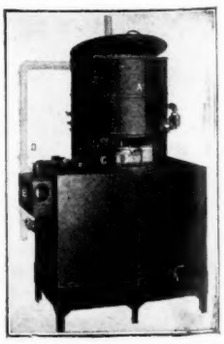


This heater is intended to supply hot water in hotels, apartment houses, factories, etc., and is designed with a number of straight tubes in the steam element of sufficient length to insure that the required heating will be taken care of and that all the steam will be condensed. The drain-tube area is only sufficient to carry the condensation back to the steam head. The brass tubes are expanded in a fixed tube plate at one end and in a floating tube plate at the other, thus permitting expansion and contraction of the tube without strain on the tube joints. The shell is finished with welded construction or riveted as preferred.

Heat Meter, New Compensated
The Brown Instrument Co., Philadelphia, Pa.
"Power," Sept. 30, 1919

This instrument eliminates the effect of line and thermocouple resistance by means of an operation that is simple and gives accurate results. In testing with this instrument, it is only necessary to connect the thermal couple with the instrument binding posts, press a button, turn a knob and take a reading, which will be the correct electromotive force of the thermal couple at its hot end, even if the line is miles in length. The line may have as much as 15 ohms resistance. The instrument is direct reading through its entire scale range, requires no dry nor standard cells.

Filter, Nugent Automatic Alarm Oil
W. W. Nugent & Co., 150 West Superior St., Chicago, Ill.
"Power," Sept. 23, 1919



This filter is equipped with an automatic alarm consisting of a tilting two-compartment tank, two gongs and a gong beater which moves with the tank. When one of the compartments fills, the tank becomes overbalanced and tilts, whereupon the beater comes in contact with a gong, thus sounding an alarm, which indicates that the oil-filtering bag is overflowing. When the second or third bag begins to overflow, the interval between alarm signals becomes shorter and the alarm is more insistent. The alarm is sounded so as to prevent the overflow of dirty oil into the filtered oil.

Patented Aug. 20, 1918

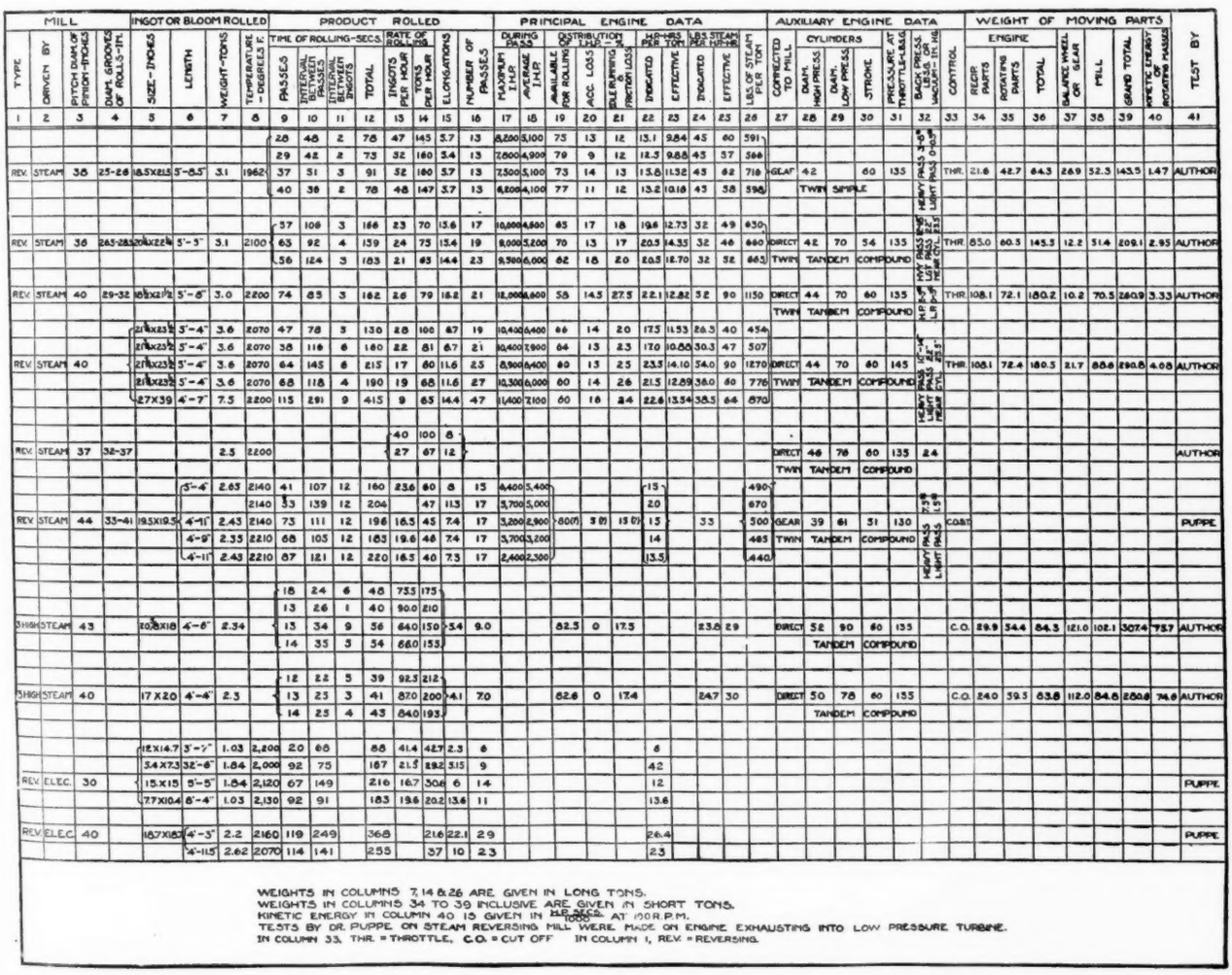
Steam Versus Electric Driven Steel Mills

At the Pittsburgh monthly meeting, Dec. 20, 1919, of the Association of Iron and Steel Electrical Engineers, a discussion was had on "Steam- Versus Electric-Driven Mills." A brief report of this meeting was published in Power, Jan. 13, 1920. After this discussion considerable time was devoted to collecting and tabulating additional material, and the results of this investigation were published recently in the association's monthly bulletin, of which this article is a brief abstract. The total discussion comprises 40 pages and 11 inserts. Copies can be obtained by addressing the association's office at 513 Empire Building, Pittsburgh, Pa.

WITH a view to contributing toward the elimination of doubts that seem to exist on some of the most essential points regarding main-roll drives for steel mills, H. E. Siebert[1] has prepared and given in his discussion a number of curves and tables which are derived from tests made on some of the largest steam-driven mills in the Pittsburgh and Youngstown districts. For the sake of comparison he has included results of tests from the work of Dr. Puppe on steam- and electric-driven mills in Europe. These curves show principal results of tests on 38-in. and 40-in. reversing blooming mills driven by steam engines. In one case the engine is a 42 x 60-in. twin-simple reversing type, throttle controlled. In another case the engine is a 44 x 70 x 60-in. twin-tandem-compound unit. Another drive analyzed is that of a 52 x 90 x 60-in. tandem-compound engine of the Corliss type, operating condensing. The latter engine drives a 43-in. three-high blooming mill, having a rolling rate of from 170 to 210 tons per hour of 2.5-ton ingots. The table, Fig. 1, gives detailed information on a number of steam and electrically driven mills. It is limited to the tests made by the author and some of the tests of Dr. Puppe, on both steam-engine driven and electric-driven mills.

In comparing the different engines in Fig. 1, it will be seen that the water rate per indicated horsepower-hour on the Mesta single-lever-controlled engine is 23 lb. and on the other heavy engines controlled by the throttle alone it is 32 to 35 lb. per indicated horsepower-hour. This comparison shows what steam economy can be effected by cutoff. The real point—steam per ton—can be obtained for any elongation by multiplying indicated horsepower-hours per ton by the water rate of the engine. The table also shows that the same compound engine, whose non-condensing water rate is 54 lb. per indicated horsepower-hour, has a condensing water rate of about 35 lb. Thus a material saving can be effected by condensing operation.

In applying these data care should be observed in the use of the figure for water rate per "effective horsepower." If



WEIGHTS IN COLUMNS 7, 14 & 26 ARE GIVEN IN LONG TONS.
WEIGHTS IN COLUMNS 34 TO 39 INCLUSIVE ARE GIVEN IN SHORT TONS.
KINETIC ENERGY IN COLUMN 40 IS GIVEN IN $\frac{LB.SEC^2}{TONS}$ AT 100 R.P.M.
TESTS BY DR. PUPPE ON STEAM REVERSING MILL WERE MADE ON ENGINE EXHAUSTING INTO LOW PRESSURE TURBINE.
IN COLUMN 33, THR. = THROTTLE, C.O. = CUT OFF IN COLUMN 1, REV. = REVERSING.

FIG. 1. DETAILED INFORMATION ON A NUMBER OF STEAM AND ELECTRICALLY DRIVEN MILLS

[1] Assistant combustion engineer, Bethlehem Steel Co., Bethlehem, Pa.

this figure is used, the "mill efficiency" should also be used, since in the case of a heavy engine having a high water rate per "effective horsepower," the mill and engine efficiency is low and in that efficiency the losses are expressed in the high water rate per "effective horsepower." In every case *indicated horsepower-hours per ton × water rate per indicated horsepower-hour = indicated horsepower-hours per ton × water rate per effective horsepower-hour × mill and engine efficiency.*

As an illustration of the relative economy of steam and electric drives the author takes that of a large plant containing 6 heavy reversing and 2 three-high drives, steam engines being the prime movers. The gross product of the plant (as rolled) can be taken as 100,000 tons per month, the greater part being shapes. The engines are compound condensing, having an average water rate of 38 lb. per indicated horsepower-hour, including condenser auxiliaries, and are in condition to give service for some years, the entire steam plant being about thirteen years old. Steam is generated in stoker-fired central boiler plants at 155 lb. gage, with an average superheat of 50 deg. F. The plant at the present time is short of electric power to the extent of about 4,000 kw., the peak being 7,000 kw. In this particular case the field is almost ideal for a central station of about 25,000 kw. The question is, "Would the economy of the electric mill drive warrant a replacement of the engines?"

In this analysis it is shown that the cost per ton of steel rolled with the steam drive is: Fixed charges, $0.14; repairs and maintenance, $0.10; lubrication, waste and miscellaneous supplies, $0.03; operating labor is taken as equal to that of the electric drive; total cost of steam per ton output, $0.93, making a grand total cost per ton for steam drive of $1.20. On the electric drive the cost per ton is: Fixed charges, $0.42; repairs, maintenance and miscellaneous supplies, $0.02; cost of current, $0.32; cost of labor is taken equal to that for steam drive, making a grand total for the electric drive of $0.76. A saving in favor of the electric drive over the steam of $1.20 — $0.76 = $0.44 per ton, which represents an interest return on the investment of 16 per cent in favor of electric drive.

The foregoing condition is considered one of the most favorable for the steam drive. For a new plant the conditions will be entirely different, at least from the standpoint of fixed charges, because both steam and electric plants will be governed by present-day prices. From the data presented in the curves and tables given in the discussion the author arrives at the following conclusions:

1. The power requirements by different mills rolling at widely different rates show very close agreement. This is especially true of the blooming and billet mills, both reversing and three-high.

2. The data show that the electric reversing mill requires just as much power per unit of elongation as the steam-driven reversing or the three-high mill.

3. The 60 per cent kinetic energy which is stored in the rotating masses of the electric reversing mill and which is reclaimed in the form of electrical energy, does not appear on the curves in favor of this form of drive. This fact is evidently due to the greater moment of inertia of the rotor masses, as compared with that of the steam-driven mills.

4. Acceleration losses in reversing steam drives vary from 12 to 36 per cent of the indicated work, for the light and heavy engines respectively. The lighter the engine is the easier it is to control and the less this loss.

5. The reversing-mill engine, especially in the form of a twin-tandem compound, is a very complicated machine, and as such it demands more attention and repair than the average mill mechanical force can possibly devote to it in the time that is available for such repairs.

The single-lever controlled engine is a forward step in the direction of steam economy, but it imposes a heavy penalty in the form of acceleration loss. Can we not build a light, yet a simple and strong engine?

6. The motor-driven mill possesses decided advantages in the way of mechanical simplicity, space required, cleanliness of plant, etc., aside from its economic advantage.

7. No fixed rule can be laid down for the relative economy of the steam and electric drives for different plants, because the plant conditions vary within wide limits. For the case taken, the advantage is in favor of the electric drive. It does not follow, however, that this advantage would obtain in another case. Each particular plant must be studied in detail. Such a study may show that the economic gain in one plant does not apply to another plant where the conditions may be different.

In his discussion the following data on steam consumption, as obtained from a 55x60-in. twin-simple-reversing engine driving a 40-in. blooming mill, were presented by B. E. Eppelsheimer[2]:

DATE—JULY 30, 1919

Average steam pressure, lb. gage	160
Duration of test, hours	17
Average feed-water temperature, deg. F	210
Total boiler-feed water, lb	1,690,000
Total loss through safety valves and blowoff	144,000
Net steam to engine, lb	1,546,000
Average steam per hour, lb	90,940
Maximum flow, steam per hour, lb	150,750
Minimum flow, steam per hour, lb	25,000
Size of ingots	18 x 20-in.
Size of blooms	7 x 4-in.
Number of ingots rolled	436
Weight of ingots rolled, tons	1,014 (FP 832)
Steam per ingot, lb	3,570
Steam per ton steel, lb	1,520

In addition to the foregoing data, obtained when the mill was rolling steel, the steam consumption was determined for the engine and mill running idle and for the engine alone with the mill disconnected. During these tests there were no reversals of the engine, so that there were no plugging strokes as in actual rolling. The steam consumption under these conditions was too small to be measured accurately by the venturi meter and was obtained by flow meters in the steam lines from the individual boilers. Since the steam flow was practically constant, this type of meter is accurate under these conditions. The results of these idle tests to determine the friction load are as follows:

Friction load	Engine and Mill	Engine Alone
Duration, minutes	20	20
Engine speed, r.p.m.	41	40
Steam per hour, lb.	36,900	29,610
Steam per revolution, lb.	15.0	12.35

This blooming-mill engine exhausts into receivers which supply steam to low-pressure turbines run condensing. Since the low-pressure steam to the turbines replaces high-pressure steam of the same total available heat energy, the blooming-mill engine should be credited with the heat

ELECTRICAL OPERATING COSTS PER TON.

YEAR	1913	1914	1915	1916	1917	1918	1919	AVERAGE	%TOTAL
MONTHS IN OPERATION	9	8	12	12	12	12	◆ 8	73	
TONNAGE	119,230	92,622	174,460	238,050	297,224	276,778	155,515	1,353,879	
K.W.H. PER TON	23.9	22.8	21.5	19.8	20.4	21.8	23.4	21.2	
POWER COST	.160	.153	.144	.133	.137	.146	.157	.1457	86.7
REPAIRS AND MAINTENANCE	.0069	.0092	.0045	.0102	.0039	.0030	.0027	.0057	8.0
MISCELLANEOUS SUPPLIES	.0045	.0049	.0025	.0025	.0029	.0015	.0051	.0032	3.4
LABOR IN OPERATION	.0141	.0161	.0128	.0100	.0128	.0147	.0146	.0134	1.9
TOTAL COST	.1855	.1832	.1638	.1557	.1566	.1652	.1794	.1680	100.00

TOTAL ELECTRICAL COSTS PER TON

YEAR	1913	1914	1915	1916	1917	1918	1919	AVERAGE	%TOTAL
TOTAL OPERATING COSTS	.185	.183	.164	.156	.157	.165	.179	.1680	49.17
INTEREST ON INVESTMENT	.078	.101	.054	.040	.032	.035	.041	.0460	13.46
DEPRECIATION (20 YEARS)	.065	.084	.045	.033	.026	.028	.034	.0383	11.21
TOTAL MAIN DRIVE	.328	.368	.263	.229	.215	.228	.254	.2523	73.84
★ MISCELLANEOUS	.126	.133	.115	.078	.061	.063	.077	.0894	26.16
TOTAL MILL ELECTRICAL CHARGE	.454	.501	.378	.307	.276	.291	.331	.3417	100.00

★ ALL OTHER ELECTRICAL CHARGES, INCLUDING OVERHEAD.
◆ UP TO AND INCLUDING AUGUST 31, 1919.

FIG. 2. DATA ON 34-IN. ELECTRICALLY-DRIVEN REVERSING MILL

[2]Steam engineer, American Rolling Mills Co., Middletown, Ohio.

energy available in the exhaust. The available energy between 160-lb. gage and 5-lb. gage through the blooming-mill engine is 43.4 B.t.u. per pound of steam. The available energy between 5-lb. gage and 28-in. vacuum to the turbine is 39.1 B.t.u. per lb. of steam. The total available energy for high-pressure steam between 160-lb. gage and 28-in. vacuum is 82.5 B.t.u. Each pound of exhaust steam used in the turbine saves 0.457 lb. of high-pressure steam.

The data presented in Fig. 2 were given by E. S. Jefferies[3], for an electrically driven 34-in. reversing mill, which has been in operation for 6½ years, during which time it has rolled 1,353,879 net tons of various sizes, varying in size from 10-in. rounds down to 4 x 4's, the average size being 5 x 5 in. This equipment has given practically no trouble, as illustrated by the fact that in the last 4½ years the total delays charged by the mill department against the equipment was 11 hours, 35 minutes, which is roughly one minute delay for every 2,000 tons rolled.

The electric cost data over the 6½-year period for an 18-in. four-stand billet mill, which is driven by a 1,600-hp. motor, through a herringbone reduction gear, and rolls 4 x 4's to 1¾ in. square, are as follows:

Total tonnage rolled—697,012 net tons		Per Cent
Repairs and maintenance	$0.0028	1.3
Labor in operation	0.0249	11.3
All power	0.1740	78.8
Interest and depreciation	0.0191	8.6
Total electrical cost	$0.2208	100.0

The total time delay on this mill is not more than one minute in a minimum of four to five thousand tons rolled.

Similar cost data during the same 6½ years for a rod and wire mill, which is a Morgan continuous mill, having ten 12-in. roughing stands and six 10-in. finishing stands, rolling 1¾-in. billets to No. 5 rods, are as follows:

Total tonnage rolled—395,925 tons		Per Cent
Repairs	$0.0175	1.7
Labor	0.0457	4.4
All power	0.8140	78.1
Interest and depreciation	0.1660	15.8
Total cost per ton	$1.0432	100.0

The electrical equipment on this mill comprises a 3,200-hp. synchronous motor driving two 1,200-kw. generators, which in turn drive two 1,600-hp. variable-speed motors controlled by the Ward-Leonard system. Here also the delays have been so few, especially in the last four years when there has been no delay charged whatsoever.

Others contributing to the discussion are: K. A. Pauly, general engineer, General Electric Co.; G. E. Stoltz, general engineer, Westinghouse Electric and Manufacturing Co.; B. C. Fennell, engineer, Nordberg Co., Milwaukee, Wis.; B. R. Shover, consulting engineer, Pittsburgh, Pa.; F. G. Cutler, steam engineer, Tenn. C., I. & R.R. Co., Birmingham, Ala.; R. H. Keil, power engineer, Jones & Laughlin Steel Co., Pittsburgh, Pa.; and Gordon Fox, electrical engineer, Steel and Tubes Company of America, Indiana Harbor, Ind.

Massachusetts Board of Boiler Rules Has Hearing in Boston

The Massachusetts Board of Boiler Rules convened in Boston, Thursday, May 6, at its semi-annual meeting to consider changes in rules. The meeting was presided over by John H. Plunkett. Two members of the board, John A. Collins and H. H. Lynch, and former Chief Inspector George A. Luck, were present.

Mr. Stetson, a representative of the Bigelow Boiler Co., New Haven, Conn., requested permission to weld longitudinal joints in vertical fireboxes of boilers and called upon F. L. Fairbanks to present the case for him. Mr. Fairbanks conceded that certain seams of boilers could be welded without danger to the structure. He said that as a whole in the welding of a firebox or inner sheet, the parts where the weld is made are in compression and the severe stresses are distributed on the staying. All large railroads allow welding of joints in flat plates in fireboxes. No trouble has been experienced and the trials have been very successful. It is now a regular practice. For several years, the A. S. M. E. did not permit welding of seams, but now allows this process if the stress is carried by the construction. In the firebox boiler when the strength is carried by the staying of the circular outside wrapper, the sheet is safer, and the Bigelow Boiler Co. feels warranted in asking permission to weld longitudinal joints of vertical fireboxes. Mr Fairbanks then went on to say that the Bigelow people were prepared to do welding by both the oxyacetylene and the electric processes. Mr. Fairbanks, who has had much experience along these lines, advocated this method for the less important seams of the boiler.

Mr. Stewart, head of the Stewart Boiler Works, Worcester, Mass., opposed the A. S. M. E. rules, for the reason that just such processes as here proposed, jeopardize the safety of boilers. If such practices are followed, the factor of safety is lost. The board had ruled in the past that the forged weld only could be used, and this shows that the board has previously considered autogenous welding unsafe. Mr. Stewart also stated that welded seams would eventually leak. As to compression this depended on the staybolts—if they are always there—but if broken they cannot support the weld. He said that he had always opposed anything in the Massachusetts rules that tends to lower the safety standard.

Fred. E. Dillon, of the Dillon Boiler Works, of Fitchburg, Mass., at this juncture asked Mr. Fairbanks if he thought that staybolts might break and not support the welded joints.

Mr. Fairbanks replied that he had thought so at one time, but that as chairman of a subcommittee of the Boiler Code Committee he had done a great deal of study and investigation work along these lines. As a result of this research work, in his opinion the furnaces of vertical-tube boilers were under compression and self-sustaining and staybolts were not necessary for the support of the firebox sheet. He said, however, that if the water were to leave the boiler, the staybolts might prevent bulging between stays and therefore were beneficial. The Massachusetts Boiler Rules permit forge welding. I have a large number of forge-welded tanks. It takes a very expensive equipment to forge weld and that is its greatest objection. I believe, however, that autogenous welding when the stress is carried by other means than the weld, is safe and reasonable. Construction should be allowed as provided for in the A. S. M. E. Boiler Code.

Mr. Fessenden, of the Petroleum Products Co., petitioned the board for permission to tap heating boilers for hot-water circulation to the oil-supply pipes in order to reduce the viscosity of the oil. He introduced Mr. Fiske, a mechanical engineer of the company, who pointed out that this arrangement of tapping is comparable with the Lamphrey mouthpiece construction but has not so many joints.

Charles E. Gorton, of the American Uniform Boiler Law Society, asked the board to consider the following amendment to the rules:

Although a boiler may not conform in all respects to the requirements of the boiler rules as they exist upon the date when this amendment is passed, yet if such boiler shall have been found upon inspection during construction by a boiler inspector duly qualified under the provision of Section 4, Chapter 465 of the Acts of 1907, as amended to conform in all respects to the Rules for the Construction of Stationary Boilers and for Allowable Working Pressures formulated by the Boiler Code Committee of the American Society of Mechanical Engineers and submitted to the Council of that Society December 3, 1918, and if such boiler shall be stamped by such inspector in accordance with the provisions of paragraph 332 of said rules, and if such boiler shall be found upon inspection by the Division of Inspections to conform in design, construction and workmanship with the requirements of said rules, then such boiler shall be certified as inspected by the Division of Inspections for operation in Massachusetts and shall be allowed a working pressure computed in accordance with said Rules for Allowable Working Pressures formulated by said Boiler Code Committee; provided, however, that where said rules conflict with any provision of the statutes of the Commonwealth of Massachusetts the latter shall apply.

[3]Electrical engineer, Steel Company of Canada, Ltd., Hamilton, Ont.

Mr. Dillon, speaking on behalf of the New England Association of Boiler Manufacturers, said that at the March meeting of that association a resolution had been passed that the past work of the Board of Boiler Rules be approved and that no acceptance of boilers of any lower standard be permitted. This was an indirect intimation that the boilers manufactured in accordance with the regulation of the A. S. M. E. Boiler Code were of an inferior quality and lower standard.

Mr. Gorton interrupted to call attention to the fact that all of the members of the New England Association of Boiler Manufacturers made boilers to the A. S. M. E. standard and asked why any manufacturer should build boilers for outside states that were unsafe and if it was necessary to prove that boilers manufactured under the A. S. M. E. Code were safe. "There are really very few differences between the boilers made under the A. S. M. E. Code and those made under the Massachusetts Code," said Mr. Gorton, and he then read a list of the sixteen states that operate under the A. S. M. E. Code.

Mr. Dillon replied that it was true that there was very little difference, but said that those were the differences to which they referred and which they wanted to preserve and that the New England Boiler Manufacturers Association stood up for Massachusetts rules.

A meeting of the executive committee will be held in the near future to reach decisions on the cases brought before the board at the hearing.

Latest New York Power Plant To Have Large Units

The two 60-cycle turbo-generators which will be installed in the new Hell Gate station of the United Electric Light & Power Co., of New York, will be of the tandem-compound type, each rated at 43,750 kva. at 80 per cent power factor or 35,000 kw. They will be designed to carry peak loads of 40,000 kw. for short periods. These units, which will be built by the Westinghouse Electric & Manufacturing Co., will be similar to the 60-cycle units installed in the Northwest station of the Commonwealth Edison Co. The generators will be designed for 13,200 volts, and the units will operate at 1,200 r.p.m.

The turbines will be designed to operate at 220 lb. steam pressure, 200 deg. F. superheat and 29 in. vacuum. They will have reaction blading throughout. The high-pressure element of this type of machine is single-flow and the low-pressure element is double-flow.

Obituary

John Wesley Hyatt, inventor of the Hyatt roller bearing, died suddenly on May 10, of heart disease, in his eighty-third year, at his residence, Windermere Terrace, Short Hills, N. J.

Personals

Barton R. Shover, Consulting Electrical, Iron and Steel Plant and Steam Engineer, Oliver Building, Pittsburgh, Pa., has added to his organization W. C. Rott as chief engineer.

Charles F. Lederer, until recently superintendent of way, of the Milwaukee (Wis.) Electric Railway and Light Co., has become associated with the rail-welding department of the Metal and Thermit Corp., of New York.

J. H. McElhinney recently resigned as chief engineer of the Youngstown Sheet and Tube Co., Youngstown, Ohio, to become chief engineer for the Columbia Steel Co., Elyria, Ohio.

G. E. Stoltz, general engineer of the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., has been appointed engineer in charge of the steel-mill section of the engineering department.

William F. Mallay, who during the war was chief engineer of the United States Destroyer "Stevens" and previous to the war was with the Lincoln Manufacturing Co., Fall River, Mass., is now in charge of the new plant of the New England Oil Refining Co.

Society Affairs

The American Society of Safety Engineers will meet on Friday, May 28, at the Engineering Societies Building, West 39th Street, New York. The meeting will be devoted to the safety features of compressed-air work in tunnel and foundation construction.

The American Society of Mechanical Engineers is planning the formation of a professional section covering the handling and distribution of material. The purpose of such a section is to attract the attention of the technical and business minds to this phase of commerce.

The Associated Manufacturers of Water Purifying Equipment will meet in Montreal, Canada, in conjunction with the annual convention of the American Water Works Association during the week of June 20. Reports of the committees on standardization of contracts and sizes of filters, together with tentative forms and schedules, will be submitted at the meeting.

The New England States Association of the National Association of Stationary Engineers will hold its annual convention at Worcester, Mass., July 8, 9 and 10, and in connection the annual exhibition of power-plant machinery, accessories and supplies will be conducted July 7, 8 and 9 under the auspices of the New England Association of Commercial Engineers. The annual meeting and election of officers will be held at this time by the N. E. A. C. E. Adequate entertainment has been planned for the delegates and visitors to the convention.

The American Welding Society at a meeting in New York City, on April 22, elected the following officers: President, J. H. Deppeler, Metal and Thermit Corp.; vice president (two-year term), J. W. Owens, Norfolk Navy Yard; vice president (one-year term), D. B. Rushmore, General Electric Co.; directors (three-year term), W. M. Baird, Linde Air Products Co.; A. M. Candy, Westinghouse Electric and Manufacturing Co.; C. J. Halsey, Electric Arc Cutting & Welding Co.; C. J. Jones, consulting engineer; C. A. McCune, Page & Wire Co.; S. W. Miller, Rochester Welding Works; Joah Bragden, David Lipton Sons Co.; P. F. Willis, Henderson-Willis Welding and Cutting Co.

The American Society of Heating and Ventilating Engineers will hold its semi-annual meeting May 26, 27 and 28 at St. Louis, Mo., in the Hotel Statler. The opening day will be devoted to registration and business meetings, reports of committees, etc. During the afternoon a joint meeting with the American Society of Refrigerating Engineers will be held, and in the evening a theatrical entertainment will be given at the Municipal Open-Air Theater, Forest Park. On Thursday there will be a joint meeting with the American Society of Mechanical Engineers and the American Society of Refrigerating Engineers, a boat ride on the Mississippi River and a banquet at the Hotel Statler, jointly with the American Society of Refrigerating Engineers. Friday will be devoted to professional sessions.

The American Boiler Manufacturers' Association will hold its thirty-second annual convention at the French Lick Springs Hotel, French Lick, Ind., May 31, June 1 and 2. The first day of the convention will be taken up by reports concerning the A. S. M. E. Boiler Code. The reports deal with the promulgation of the Code, simplification of data sheets, stamping of boilers, etc. A paper on "Fuel Conservation" will be presented by David Moffat Myers, consulting engineer, New York. In the afternoon delegates may indulge in tennis, bathing, riding, croquet and other sports. During the third session on Tuesday, June 1, the reports of the treasurer and of the auditing committee will be read. This session is for members only. The last day of the convention will be given over to the report of the nominating committee and the election and installation of officers.

Miscellaneous News

The Pensylvania State College is opening a two weeks' summer course in Industrial Organization and Management from Aug. 9 to 21. It is designed to meet the needs of manufacturers, superintendents, employment directors, foremen, accountants, and all others who are concerned with the daily affairs of industry and who are willing to devote two weeks to intensive study.

The Franklin Institute at a meeting on May 19, presented the Franklin Medal to Sir Auckland Geddes, British Ambassador, on behalf of the British government for the Honorable Sir Charles A. Parsons, Newcastle-on Tyne, England, and to W. A. F. Ekengren, Minister of Sweden on behalf of the Swedish government for Professor Svante August Arrhenius, Noble Institute, Stockholm, Sweden.

Engineering Council, in the referendum on a National Department of Public Works conducted by the United States Chamber of Commerce, voted in favor of a Department of Public Works established by the National Government. The Council also favored a Department of Public Works to be established by a suitable modification of the existing Department of the Interior but was opposed to the creation of an entirely new department.

Business Items

The Steam Motors Co., Springfield, Mass., announces the opening of a new office at 50 Church St., New York City.

The Dwight Manufacturing Co., of Chicago, has moved its business offices from 12 and 14 South Jefferson St. to 565 West Washington Boulevard. The new quarters are larger, and the company will have better facilities for taking care of a greatly increased business.

Trade Catalogs

The Joseph H. Roach & Company, Inc., Philadelphia, Pa., has completed publication of a new 15-page catalog entitled "The Roach Stoker." The booklet contains illustrations and descriptions of the stokers handled by this company. A copy will be sent on request.

The Metal & Thermit Corp., New York City, has issued a third and revised edition of its pamphlet entitled "Laboratory Experiments with the Thermit Process of Welding." The pamphlet illustrates and describes various experiments which are intended to show the speed of reaction, the heat produced thereby and effect obtained by superheated liquid slag and superheated liquid steel.

COAL PRICES

Prices of steam coals both anthracite and bituminous, f.o.b. mines, unless otherwise stated, are as follows:

ALANTIC SEABOARD

Anthracite—Coals supplying New York, Philadelphia and Boston:

	Mine
Pea	5.30
Buckwheat	$3.40@$3.75
Rice	2.75@ 3.25
Barley	2.25@ 2.50
Boiler	2.50

Bituminous—Steam sizes supplying New York, Philadelphia and Boston:

Latrobe	$4.25@$4.50
Connellsville coal	4.25@ 4.50
Cambrias and Somersets	4.35@ 5.15
Clearfields	4.00@ 4.75
Pocahontas	6.50@ 7.00
New River	6.50@ 7.00

BUFFALO

Bituminous—Prices f.o.b. Buffalo:

Pittsburgh slack	$6.00
Mine-run	6.25
Lump	6.00@ 6.50
Youghiogheny	6.75

CLEVELAND

Bituminous—Prices f.o.b. mines:

No. 6 slack	$3.25@$4.00
No. 8 slack	4.25
No. 8—¾-in.	3.50@ 4.00
No. 6 mine-run	3.50@ 4.00
No. 8 mine-run	4.50
Pocahontas—Mine-run	3.25@ 4.00

ST. LOUIS

Anthracite—Probably not more than 20 per cent of the demand in this market can be supplied. Prices effective Apr. 1 were as follows:

	Williamson and Franklin Counties	Mt. Olive and Staunton	Standard
Mine-run	$2.65@2.80	$3.00@3.50	$3.75@4.25
Screenings	2.50@2.65	2.50@3.00	2.75@3.50
Lump		3.75@4.50	4.00@4.50

Williamson-Franklin rate to St. Louis is $1.10; Other rates 95c.

CHICAGO

Bituminous—Prices f.o.b. mines:

		Freight rate Chicago
Illinois		
Southern Illinois		
Franklin, Saline and Williamson Counties		
	Mine-Run $3.00@$3.10	$1.55
	Screenings 2.60@ 2.75	1.55
Central Illinois		
Springfield District		
	Mine-Run $2.75@$3.00	$1.32
	Screenings 2.50@ 2.60	1.32
Northern Illinois		
	Mine-Run $3.50@$3.75	$1.24
	Screenings 3.00@ 3.25	1.24
Indiana		
Clinton and Linton		
Fourth Vein		
	Mine-Run $2.75@$2.90	$1.27
	Screenings 2.50@ 2.65	1.27
Knox County Field		
Fifth Vein		
	Mine-Run $2.75@$2.90	$1.37
	Screenings 2.50@ 2.60	1.37
Brazil Block	$4.25@$4.50	$1.27

New Construction

PROPOSED WORK

R. I., Providence—The Packard Motor Car Co., B'way and 61st St., will soon award the contract for the construction of a 2 story service station on Elmwood Ave. A steam heating system will be installed in same. Total estimated cost, $100,000.

N. Y., Brooklyn—B. F. Keith, 1564 Bway., New York City, plans to build a theatre on Gold, Fleet and Prince Sts. A steam heating system will be installed in same. Total estimated cost, $750,000.

N. Y., Buffalo—The Buffalo Shoe Hospital, 509 Main St., is in the market for a 3 hp., 60 cycle, single phase, 220 volt motor.

N. Y., Buffalo—The Niagara & Erie Power Co., 1600 Marine Trust Bldg., is having plans prepared for the constuction of a high tension system. Estimated cost, $250,000.

N. Y., Buffalo—The Niagara, Lockport and Ontario Power Co., 1600 Marine Trust Bldg., is preparing plans to double their cables between Lyons and Syracuse, to meet industrial demands. Total estimated cost, $300,000.

N. Y., Ithaca—The New York State Gas & Electric Corp. of Ithaca has made application to the Pub. Serv. Comn., 2nd Dist. for permission to mortgage and issue $2,600,400 bonds to improve plant.

N. Y., New York—The Audubon Sporting Club, c/o David F. Lang, Archt. and Engr., 110 West 34th St., plans to build a 2 story, 100 x 175 ft. club and arena at 145th St. and Lexington Ave. A steam heating system will be installed in same. Total estimated cost, $300,000.

N. Y., New York—F. Begrisch and C. L. Acker, 200 B'way, plan to build a 12 story office building on 36th St. and 5th Ave. A steam heating system will be installed in same. Total estimated cost, $3,500,000.

N. Y., New York—The Bronx Society for Prevention of Cruelty to Children, 355 East 137th St., plans to build a 7 story, 96 x 134 ft. home on Park Ave. and 16th St. A steam heating system will be installed in same. Total estimated cost, $350,000.

N. Y., New York—Sam Harris and Irving Berlin, 226 West 42nd St., are having plans prepared for the construction of a 2 story, 100 x 100 ft. theatre at 239 West 45th St. A steam heating system will be installed in same. Total estimated cost, $400,000.

N. Y., New York—F. Savignano, Archt. 6005 14th Ave., Brooklyn, plans to build a 12 story hotel on 72nd St. and Columbus Ave. A steam heating system will be installed in same. Total estimated cost, $650,000. Owner's name withheld.

N. Y., Schenectady—The Bd. Educ. will receive bids for the construction of a 126 x 175 ft. building, 2 story anemic section, 45 x 80 ft. auditorium at the Mt. Pleasant School, here. Heating and power systems will be installed in same. Total estimated cost, $400,000. E. G. Atkinson, 426 State St., Archt.

N. Y., Sodus—The Wayne Power Co. has obtained permission from the Pub. Serv. Comn., to construct electric light plants in the towns of Fremont, Howard, Hornellsville and Steuben County.

N. Y., Tonawanda—The Tonawanda Power Co. plans to increase equipment in power plant. Estimated cost, $150,000.

N. J., Newark—The Bd. Educ., City Hall, will have plans prepared for the construction of a school building on Oliver St. A steam heating system will be installed in same. Total estimated cost, $400,000. John H. and Wilson C. Ely, Firemans Trust Bldg., Archts.

N. J., Newark—The Bd. of Educ., City Hall, will receive bids until June 8 for the construction of a 3 story, 219 x 222 ft. school building on 1st and 2nd Sts. A steam heating system will be installed in same. Total estimated cost, $1,125,000. John H. and Wilson C. Ely, Firemans Trust Bldg., Archts.

N. J., Newark—The Pub. Serv. Corp. of New Jersey, Terminal Bldg., plans to construct a power plant. A steam heating system will be installed in same. Total estimated cost, $15,000,000.

N. J., South River—The Bd. Pub. Wks. and the Boro. Council received bids (lowest 3) for the construction of a turbine engine plant at the power house (all work), from John R. Proctor Eng. Co., 74 Cortland St., $197,368, Equity Eng. Co., 30 Church St., $211,726, Leslie Stevens Co., 120 B'way, $214,900; for installing turbo generators, Kerr Turbine Co., 30 Church St., $36,550, Genl. Electric Co., 120 B'way, $40,570, N. W. Kellogg Co., 90 West St., $46,465, contractors all of New York City; boiler, Babcock & Wilcox, 85 Liberty St., New York City, $29,908, Pardell Corp., 304 Bailey Bldg., Phila., $30,556; soot blowers, Babcock & Wilcox, $1,835; condensers and air circulating pumps, Wheeler Condenser & Eng. Co., 149 B'way, New York City, $19,350. Noted May 3.

Pa., Philadelphia—J. A. Wetmore, Supervising Archt., Treasury Dept., Wash., D. C., will receive bids until June 1 for the installation of a motor driven triplex pump at the United States Post Office, here.

Pa., Washington—The Hazel Atlas Glass Co. plans to build a 1 and 2 story, 100 x 368 ft. glass factory. A steam heating system will be installed in same. Total estimated cost, $500,000.

Md., Baltimore—McCawley & Co., Lombard and Commerce Sts., is having plans prepared for the construction of a 4 story, 175 x 190 ft. shirt factory on North Ave. and Wolfe St. A steam heating system will be installed in same. Total estimated cost, $500,000. Lockwood, Greene & Co., 101 Park Ave., New York City, Archts.

Va., Norfolk—C. N. Whitehurst & Co., 225 Plume St., plans to build a 12 story office building on York and Bush Sts. A steam heating system will be installed in same. Total estimated cost, $750,000. Herts & Robertson, 331 Madison Ave., New York City, Archts. and Engrs.

Va., Richmond—Herts & Robertson, Archts., 331 Madison Ave., New York City, plans to build a 6 story professional office building. A steam heating system will be installed in same. Total estimated cost, $400,000. Owner's name withheld.

N. C., Greensboro—The Revolution Cotton Mills is in the market for 2 new boilers. G. P. Stone, Supt.

Fla., St. Petersburg—The Citizens Ice & Cold Storage Co. plans to increase its plant by the addition of a 75 ton ice plant.

Fla., West Palm Beach—Paris Singer plans to build a dredging and cold storage plant here. Estimated cost, $350,000.

La., New Orleans—Farrot & Levandais, Archts., Title Guarantee Bldg., will soon award the contract for the construction of an 8 story cotton exchange building, for the New Orleans Cotton Exch., Weis Bldg. A steam heating system will be installed in same. Total estimated cost, $1,500,000.

O., Cleveland—The Cleveland Ry. Co., Leader-News Bldg., will receive bids until May 27 for the construction of a 1 story, 44 x 67 ft. electric sub-station on East 99th St. and St. Clair Ave. Two 1,500 kw. rotary converters with blowers and generators will be installed in same. Total estimated cost, $100,000. L. P. Crocelius, 650 Leader-News Bldg., Archt. and Engr.

O., Cleveland—The Lutheran Hospital Co., c/o F. W. George, 2609 Franklin Ave., plans to build a 4 story hospital. A steam heating system will be installed in same. Total estimated cost, $200,000. W. S. Longer, Marshall Bldg., Archt. and Engr.

O., Cleveland—The Tifereth Israel Association, c/o Rabbi Silver, East 55th St. and Central Ave., is having plans prepared for the construction of a 2 story, 140 x 200 ft. temple on East 105th St. and Ansel Rd. A steam heating system will be installed in same. Total estimated cost, $1,000,000. Hubbell & Benes, 4500 Euclid Ave., Archts.

O., Galion—The City Council has autnorized an expenditure of $75,000 for the enlargement of the electric light plant. A $60,000 bond issue will be voted upon for this project.

O., Sidney—The C. B. De Weese Co. is having plans prepared for the construction of a 3 story, 83 x 166 ft. office and theatre building. A steam heating system will be installed in same. Total estimated cost, $200,000. J. O. Adam, New Southern Hotel, Columbus, Archt.

O., Solon—The Solon Tire Co., Union Bldg., Cleveland, is having plans prepared for the construction of a 2 story, 100 x 300 ft. factory and boiler house. Two 150 hp. boilers will be installed in same. Total estimated cost, $125,000. Donald C. Smith, Lennox Bldg., Cleveland, Archt. and Engr.

O., Toledo—The Toledo Ry. & Light Co. plans to construct a sub-station to replace the Casino Sta. recently destroyed by fire. The new station will have a capacity of 10,000 kw. and will serve the lower town industries, the new intercepting sewerage pumping station and the Toledo Beach car line. Estimated cost, $225,000. C. Derge, Asst. Genl. Mgr.

Ind., Gary—Z. Erol Smith, 305 East 55th St., Chicago, will soon award the contract for the construction of a 1 story, 50 x 400 ft. factory for the O. K. Giant Battery Co., 515 B'way. A steam heating system will be installed in same. Total estimated cost, $75,000.

Mich., Detroit—Dodge Bros., Joseph Campau Ave., plan to construct a 100 x 100 ft. power house. Four 12,000 hp. steam turbines, four 12,000 hp. boilers, automatic coal handling conveyors, stokers, and ash handling conveyors and complete steam driven, turbo-generator sets will be installed in same. Total estimated cost, $2,000,000.

Mich., Detroit—The Newton Packing Co., 1041 14th Ave., will soon award the contract for the construction of a 1 story, 68 x 95 ft. packing house on 14th Ave. An electric power motor will be installed in same. Total estimated cost, $40,000. Mildner & Eisen, 924 Hammond Bldg., Archts.

Mich., Detroit—The Sacred Heart Seminary, 155 McDougal Ave., engaged Donaldson & Meier, Archts., 1314 Penobscot Bldg., to prepare plans for the construction of a 3 and 4 story seminary on Linwood Ave. and Joy Rd. Plans include a separate steam heating plant. Total estimated cost, $2,500,000. W. W. Walker, Chn.

Mich., Detroit—Julius Stroh, 1676 Jefferson Ave., plans to build an 18 story, 80 x 100 ft. office building at the West Grand Circus Park. Steam heating equipment will be installed in same.

Mich., Highland Park (Detroit P. O.)—John H. Kunsky, 501 Madison Theatre Bldg., engaged C. Howard Crane, Archt., Huron Bldg., to prepare plans for the construction of a 2 story, 127 x 200 ft. theatre on Woodward and Waverly Aves. A steam heating and forced ventilation system will be installed in same. Total estimated cost, $300,000.

Mich., Saginaw—The Herzog Art Furniture Co., 1900 South Michigan Ave., will soon award the contract for the construction of a 3 story, 85 x 227 ft. factory. Steam heating boilers, electric power, etc., will be installed in same. Total estimated cost, $95,000. Cooper & Beckbissinger, 114 South Jefferson St., Archt.

Ill., Chicago—Graham, Anderson, Probst & White, Archts., 1417 Ry. Exch. Bldg., will soon award the contract for the construction of a 6 story, 73 x 100 ft. office building at 325 South Wells St. for the Pennsylvania Offices, Inc. A steam heating system will be installed in same. Total estimated cost, $350,000.

Ill., Lockport—The Penitentiary Comn. will receive bids until June 1 for the furnishing and installation of four 300 hp. water tube boilers and stokers in the power house at the Illinois State Penitentiary, near here.

Wis., Milwaukee—The Central Bd. of Purchases received bids May 10 for furnishing a 1,500 gal. combination motor driven street flusher and sprinkler, from the Pauly Motor Truck Co., 2530 North Ave., $8,775; Sterling Motor Truck Co., 46th Ave. and Rogers St., West Allis, $9,427; Amer. Auto Co., 187 Wisconsin St., $9,969.

Wis., Milwaukee—The Federal Eng. Co., Engr., Stephenson Bldg., will soon award the contract for the furnishing of coal conveying machinery for the Natl. Knitting Co., 905 Clinton St.

Minn., Chisholm—Ernest Drew, Town Recdr., will receive bids until July 1 for the construction of a 2 story, 64 x 298 ft. building on Lake St. A steam and mechanical ventilating system will be installed in same. Total estimated cost, $450,000.

Minn., St. Paul—The Times Auto Supply Co., 56th and B'way, New York City, is having preliminary plans prepared for the construction of a 6 story, 98 x 130 ft. office-warehouse on St. Peter and 6th Sts. A steam heating system and electric motors will be installed in same. Total estimated cost, $300,000. Toltz, King & Day, 1410 Pioneer Bldg., Archts.

Kan., Americus—The city voted $18,000 bonds to build an electric transmission line from here to Emporia. Noted May 10.

N. D., Grand Forks—The Industrial Comn. of North Dakota, Bismarck, will receive bids until May 29 for the construction of a reservoir, filter plant, power house and plant. Boilers, stokers, etc., will be installed in same. C. L Pillsbury Co., 2305 Oliver Ave., S., Minneapolis, Minn., Engr.

Mo., St. Louis—The city plans to install one 220 hp. engine and a horizontal single crank engine for the pumping station. J. A. Brooks, Engr.

Cal., San Diego—Tne Bureau of Yards & Docks, Navy Dept., Wash., D. C., plans to install cold storage insulation. Estimated cost, $125,000.

Cal., San Francisco—The Pacific Gas & Electric Corp., 445 Sutter St., plans to improve and construct additions to the electrical generating and distributing system, including hydro-electric plants along the Pitt River, transmission lines, etc. Total estimated cost, $13,062,426. John Britton, Vice-Pres.

M. I., Guam—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., will soon award the contract for the installation of turbo alternators, exciters and switchboards. Estimated cost, $33,000.

Ont., London—J. M. Moore, Archt., 425 Richmond St., will receive bids until May 31 for the construction of a 4 story, 75 x 180 ft. hospital on St. James St. Boilers, radiators, etc., will be installed in same. Total estimated cost, $160,000.

Ont., Toronto—The Famous Players Canadian Corp., Temple Bldg., is having plans prepared for the construction of a 2 story motion picture theatre. A steam heating system will be installed in same. Total estimated cost, $300,000. J. M. Jeffrey, 348 Confederation Life Bldg., Archt.

Ont., Wroxeter—The Town Council plans to build a power plant. Estimated cost, $15,000. Mr. Flint, Hydro Bldg., Toronto, Engr.

CONTRACTS AWARDED

Mass., Boston—Snider & Druker, 18 Tremont St., will build an 8 story, 60 x 100 ft. mercantile building on Kneeland Ave. A steam heating system will be installed in same. Total estimated cost, $500,000. Work will be done by day labor.

Mass., Boston—Swift & Co., 60 North Market St., has awarded the contract for the construction of a 2 story office building and a 2 story extension to boiler room, to the R. F. Morrison Co., City Sq. Bldg. Total estimated cost, $18,000.

Mass., New Bedford—The Empire Theatre Inc., 2 Masonic Bldg., has awarded the contract for the construction of a 2 story, 70 x 140 ft. theatre on Elm St., to the Weiss Constr. Co., 40 Court St., Boston. A steam heating system will be installed in same. Total estimated cost, $325,000.

Mass., South Boston (Boston P. O.)—The Joseph Burnett Co., 36 India St., Boston, has awarded the contract for the construction of a 7 story, 80 x 160 ft. manufacturing building on Fargo and "L" Sts., to the William M. Bailey Co., 88 Broad St., Boston. A steam heating system will be installed in same. Total estimated cost, $400,000.

N. Y., New York—Crawford, Russell, Weaver & Everett, 2 West 42nd St., will build two buildings, one 31 story and the other 25 story on Park and Madison Aves., 45th to 47th Sts. A steam heating system will be installed in same. Total estimated cost, $25,000,000. Work will be done by day labor.

N. Y., New York—The New York Edison Co., Irving Pl. and 15th St., has awarded the contract for the construction of a 3 story, 45 x 75 ft. transformer station on East 6th St., to Clough Bourne, 101 Park Ave. Estimated cost, $60,000. Noted Feb. 9.

N. Y., New York—The Vincent Astor Estate, 23 West 26th St., has awarded the contract for changing the 14 story hotel on 42nd St. and B'way into an office building, to Marc Eidlitz, 30 East 42nd St. A steam heating system will be installed in same. Total estimated cost, $200,000.

N. Y., St. Margaret's Bay—The Novo Scotia Power Comn., Halifax, has awarded the contract for the construction of a power house, etc., in connection with the proposed hydro-electric development, to D. G. Loomis & Sons, 1112 St. Patrick St., Montreal, P. Q. Total estimated cost, $250,000.

O., Cleveland—The Cleveland Rubber Corp. Co., 1900 Euclid Ave., has awarded the contract for the construction of a 1 story, 52 x 103 ft. boiler house at 2110 West 114th St., to the U. S. Eng. & Constr. Co., Engineers Bldg. Estimated cost, $50,000.

Mich., Saginaw—St. Mary's Parish has awarded the contract for the construction of a 3 story, 114 x 125 ft. parish school building, to the Burnett-Heinge Co., Main St. A steam heating boiler, fan system, etc., will be installed in same. Total estimated cost, $175,000.

Ia., Waterloo—Deere & Co., 1325 3rd Ave., has awarded the contract for the construction of a group of foundry buildings including a 3 story, 120 x 120 ft. service building, etc., to the Scales Constr. Co. Circulating fans and motors will be installed in same. Total estimated cost, $400,000.

Neb., Ingleside—The Bd. of Comrs. of the State Institutions has awarded the contract for the installation of a heating system in the proposed hospital and receiving building, to Phelps & Underwood, at $24,000.

Tex., Austin—The State Bd. of Control has awarded the contract for the installation of a complete heating system in the lunatic asylum here, to John L. Martin, 408 Congress Ave., at $47,500. Noted May 3.

Cal., Westend (San Rafael P. O.)—The Westend Mining Co. has awarded the contract for the construction of a borax plant to John Simpson & Co., Grant Bldg., Los Angeles. Plans include an 80 x 180 ft. mill building, 32 x 48 ft. boiler house, etc.

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